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NATIONAL DAM SAFETY PROGRAM. WOODCLIFF LAKE DAM (NJ00247). HACK--ETC(U)

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1 OF 2

AD A058153

HACKENSACK RIVER BASIN

PASCACK BROOK, BERGEN COUNTY

NEW JERSEY



# WOODCLIFF LAKE DAM

## PHASE I INSPECTION REPORT
## NATIONAL DAM SAFETY PROGRAM

NJ00247





DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

JUNE 1978

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

81 JUL 1978

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621



Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Woodcliff Lake Dam, Bergen County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given on the first pages of the report.

Based on visual inspection, available records, calculations, and past operational performance, Woodcliff Lake Dam is judged to be in fair condition. The dam's spillway is considered seriously inadequate as 32 percent of the Probable Maximum Flood (PMF) would overtop the dam. To insure adequacy of the structure, the following actions, as a minimum are recommended:

a. Hydrologic and hydraulic investigations and engineering studies should be completed within twelve months of the date of approval of this report to determine corrective action required to increase the capacity of the spillway. Construction of an improved spillway should commence in calendar year 1979. Due to the potential for overtopping of the dam, a detailed emergency operation, warning and evacuation system should be developed and placed into operation by the owner within the next three months.

b. Engineering studies should be completed within six months of the date of approval of this report to determine the engineering properties of the embankment materials, the location of the phreatic line and determine the stability of the embankment. Necessary remedial measures should be initiated within 6 months of completion of these studies. The seepage areas should be monitored regularly until corrective measures are adopted. To facilitate seepage monitoring, the left downstream embankment area to 50 feet beyond the toe of the dam should be cleared, regraded and reseeded as required.

NAPEN-D
Honorable Brendan T. Byrne

c. Piezometers or observation wells should be installed in the embankment near the left abutment as part of the studies recommended in paragraph b. above.

d. The following items should be accomplished within one year from the date of approval of this report:

(1) The erosion at the end of the spillway chute and in the downstream channel should be repaired and protected from future erosion. The downstream sheet pile cut-off should be repaired and an energy dissipation sill installed.

(2) The downstream embankment should be cleared of trees and brush and a suitable vegetative cover established.

(3) Burrowing animals should be destroyed and their holes backfilled.

(4) The water level recorder in the gaging station should be repaired.

(5) The owner should upgrade his Operation and Maintenance procedures by issuing an Operation and Maintenance Manual.

e. The low level outlet valving should be relocated to the upstream side of the dam's core wall. A study should be made to determine the best method to accomplish this relocation within one year from the date of approval of this report. The valve relocation should be completed within calendar year 1979.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Andrew Maguire of the Seventh District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, thirty days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NITS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

NAPEN-D
Honorable Brendan T. Byrne

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely yours,

Harry V Dutchyshyn

HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Cy furn:
Mr. Dirk C. Hofman, P.E.
Department of Environmental Protection

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

| | |
|---|---|
| Name of Dam: | Woodcliff Lake Dam, I.D. NJ 00247 |
| State Located: | New Jersey |
| County Located: | Bergen |
| Stream: | Pascack Brook |
| Date of Inspection: | May 2 and 6, 1978 |

Assessment of General Condition of Dam with Respect to Safety and Recommended Action with Degree of Urgency

The general safety of Woodcliff Lake Dam is considered questionable in view of its lack of spillway capacity to pass the PMF, and is capable of only passing a flood equal to 31 percent of the PMF without overtopping the dam. The dam stability cannot be assessed on the basis of the available engineering data. A seepage source on the left abutment could affect the stability adversely and should be studied. The low level outlet is valved downstream of the dam's core wall, which is considered a safety hazard.

On the positive side, the dam has been in service for 73 years, and has performed adequately, although modifications in the spillway were and are required. The stream channel downstream of the spillway chute channel has been damaged and should be regraded to assure the continued safety of the installation. Suggested remedial actions are listed Section 7 together with a suggested timetable for their completion.

STATE OF NEW JERSEY
ROBERT GERSHOWITZ
20812
PROFESSIONAL LICENSED

Robert Gershowitz, P.E.

Robert Gershowitz, P.E.

(CONTINUED)

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APPROVED: Harry V Dutchyshyn
HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

DATE: 31 July 1978

W O O D C L I F F   L A K E   D A M

EMBANKMENT AND LOW LEVEL OUTLET-SPILLWAY
IS OUT OF VIEW ON PICTURE'S LEFT SIDE

HACKENSACK RIVER BASIN
WOODCLIFF LAKE DAM
BERGEN COUNTY, NEW JERSEY
INVENTORY NUMBER: NJ00247

# PHASE I INSPECTION REPORT
# NATIONAL DAM SAFETY PROGRAM

Prepared by
HARRIS-ECI ASSOCIATES
Woodbridge, New Jersey
for
DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA

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ASSESSMENT OF GENERAL CONDITION OF DAM WITH RESPECT TO SAFETY AND RECOMMENDED ACTION WITH DEGREE OF URGENCY

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PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

WOODCLIFF LAKE DAM, I.D. NJ 00247

## SECTION 1

## 1. PROJECT INFORMATION

### 1.1 General

a. Authority

The Dam Inspection Act, Public Law 92-367 of August 1972 authorizes the Secretary of the Army, through the Corps of Engineers to initiate a national program of dam inspections. Inspection for Woodcliff Lake Dam were carried out under Contract DACW61-78-C-0100 to the Department of the Army, Philadelphia District, Corps of Engineer by the engineering firm of Harris-ECI Associates of Woodbridge, New Jersey.

b. Purpose of Inspection

The purpose of the inspection and evaluation is to identify conditions which threaten the public safety and thus permit the correction of the conditions in a timely manner by the owners. The National Inventory of Dams will be updated by the data acquired during the inspection.

### 1.2 Description of Project

a. General Description of Dam and Appurtenances

Woodcliff Lake Dam is an earth embankment dam impounding the waters of Pascack Brook. The dam has an overall length of approximately 1,500 ft.

and a maximum depth above the stream bed of 38 ft. The top of the dam is 24 ft. wide and the upstream and downstream slopes are 2 horizontal on 1 vertical. The top of the dam is paved with a 2-lane bituminous roadway and is named Church Road. The upstream face is protected by cobble stone paving while the downstream face has a 12-inch surface layer of loam to support protective vegetation. In addition to the concrete core wall, headwater cut-off is achieved by interlocking sheet piling to an undetermined depth below the stripped ground surface. The sheet piling is embedded into a concrete core wall for a distance of approximately 4 feet, according to an available original plan prepared in 1903. The horizontal extent of the core wall and steel sheet piling is undetermined, and not shown on the plans uncovered in this phase. The dam abutments are formed of naturally higher ground. The spillway consists of an ungated low broadcrested concrete weir with a crest elevation at 94.33 feet east of the right abutment contact line. The spillway is surmounted by a four-span steel beam bridge resting on three intermediate concrete piers which carries Church Road across the spillway. The net spillway length is 79 feet and the spillway crest has a clear opening height between crest and bridge beam soffits of approximately 5 feet. A spillway chute connects the spillway crest to the Pascack Brook channel by turning through a 60-degree angle to the left, downstream of the crest. The total length of the spillway chute is approximately 650 feet measured from the center line of Church Road, and the chute drops a total of approximately 32 feet. in elevation.

The spillway chute has been modified twice since its original construction. In 1937, a steel sheet pile cut-off was added to the bottom end of the chute and an earth access road was added alongside the right spillway Chute wall. In 1976, the spillway chute was repaved adding 5 inches of concrete dowelled into the existing slab. At that time,

the right stilling basin wall was heightened by 2.5 feet in the area where the chute turns through an angle of approximately 60 degrees, to prevent overtopping caused by supercritical flow standing waves. On November 8, 1977, during a severe rainstorm, the increased water velocity attained in the spillway chute by the smoother repaving caused considerable local damage on both sides of the channel downstream of the chute walls removing bank areas approximately 30-ft. wide by 100-ft. long, and redeposited the coarser fractions 75 ft. to 100 ft. downstream in the channel. The increased velocity also tore away the top edge of the steel sheet piling from the end of the chute slab concrete and bent it downstream.

The approach channel to the spillway crest consists of the upstream face of the dam embankment with its stone protection, flanked by the abutment walls of the spillway bridge.

The low level outlet consists of a 48-inch diameter cast iron line passing through the dam and controlled by two 36-inch diameter gate valves installed in series in a small gate house on the downstream side of the dam. The inlet end of the 48-inch line is located at the upstream toe of the slope of the embankment dam according to a 1903 original design drawing supplied by the owner. The outlet line has an invert at elevation 63.0 and the upstream embankment is protected in its vicinity by a small concrete apron slab with head and wingwalls. There are no trash rack provisions. On the discharge side, the low level outlet channel utilizes in part the original bed of Pascack Brook which has been protected by some stone armoring along its banks and invert.

The reservoir at Woodcliff Lake Dam impounds 2,750 acre feet of water from a tributary area of 19.4 square miles. The reservoir is traversed by a causeway that cuts the reservoir in half. The two parts of the causeway are connected by an arched culvert 25-foot wide by 16.8-foot high.

b. Location

Woodcliff Lake Dam is located on Pascack Brook, a tributary of the Hackensack River at Hillsdale, Bergen County, New Jersey. The nearest downstream community is Hillsdale itself and there are urbanized areas extending almost to the end of the spillway chute.

c. Size Classification

Woodcliff Lake Reservoir is classified as being "Intermediate" on the basis of its reservoir storage volume, which is less than 50,000 acre feet but more than 1,000 acre feet. It is classified as "Small" on the basis of its total height which is less than 40 feet. The larger of the two size determinations governs, and thus the dam is classified as "Intermediate" on size.

d. Hazard Classification

In the National Inventory of Dams, Woodcliff Lake Dam has been classified as having a High Hazard Potential on the basis that failure of the dam would cause excessive property damage to residences downstream, and could potentially cause more than a few deaths.

e. Ownership

Woodcliff Lake Dam is owned by the Hackensack Water Company, located in Weehawken, New Jersey.

f. Purpose of Dam

The purpose of the dam is to impound water for use in a water supply system operated by the Hackensack Water Company. The impounded water is released by means of the bottom outlet for subsequent use downstream by way of the natural channel of Pascack Brook, and is impounded again at Oradell Reservoir on the Hackensack River.

g. Design and Construction History

Drawings provided by the owner show that the dam was designed in 1903 by the engineering firm of Hering & Fuller. New York, New York. The dam was built in 1905 by the Fuller Construction Company using horsedrawn equipment according to the owner. The embankment shown on the plans is apparently unaltered, although the curved left abutment alignment shown on the 1903 plans was not carried out, and the dam was constructed on a straight centerline alignment throughout. The original spillway chute was modified twice since its construction, in 1937 and again in 1976, as has been described above. Plans for these modifications have been provided by the Owner and are appended as Drawings 5, 6 and 7. In 1976, plans were drawn up to install 12-inch high flash boards on the spillway crest. These flash boards were in use for a short time, but are not currently is use. No original computations are available for review and no inspection reports bearing on the construction have been uncovered.

The Hackensack Water Company in 1977 initiated an investigation to augment the spillway capacity of the dam and made a detailed topographic survey of the right abutment area as part of the study. Plans for providing auxiliary spillway capacity have not been finalized as of the date of this inspection report.

h. Normal Operational Procedures

The dam is used as an impounding reservoir designed to store the maximum possible amount of surface runoff from Pascack Brook. The reservoir levels are regulated in conjunction with the needs of Oradell Reservoir which impounds waters from Pascack Brook and the Hackensack River.

## 1.3 Pertinent Data

a. Drainage Areas

At dam site, the drainage areas are 19.4 square miles.

b. Discharge at Damsite

| | |
|---|---|
| Maximum known flood at damsite: | Est. at 2,740 cfs at spillway on 11/8/77. Reservoir pool est. at Elev. 98.7 |
| Warm water outlet at pool elevation: | NA |
| Diversion tunnel low pool outlet at pool elevation: | NA |
| Diversion tunnel outlet at pool elevation: | NA |
| Gated spillway capacity at pool elevation: | NA |
| Gated spillway capacity at maximum pool elevation: | NA |
| Ungated spillway capacity at maximum pool elevation: | 1,650 cfs |
| Total spillway capacity at maximum pool elevation: | 1,650 cfs |

c. Elevation (feet above MSL)

| | |
|---|---|
| Top of dam: | 100 |
| Maximum pool-design surcharge: | 98.03 |
| Full flood control pool: | NA |
| Normal pool: | 94.33 |
| Spillway crest (gated): | NA |
| Upstream portal invert diversion tunnel: | NA |
| Downstream portal invert diversion tunnel: | NA |
| Streambed atcenterline of dam: | 62 |
| Maximum tailwater: | Unknown |

d. Reservoir

| | |
|---|---|
| Length of maximum pool: | 6,000 feet |
| Length of normal pool: | 5,000 feet |
| Length of flood control pool: | NA |

e. Storage (acre-feet)

| | |
|---|---|
| Normal pool: | 2730 AF |
| Flood control pool: | NA |
| Design Surcharge: | 3240 AF |
| Top of dam: | 3640 AF |

f. Reservoir Surface (acres)

| | |
|---|---|
| Top of dam: | 217 A |
| Maximum pool: | 200 A |
| Flood-control pool: | NA |
| Recreation pool: | NA |
| Spillway crest: | 169 A |

g. Dam

| | |
|---|---|
| Type: | Earth embankment with center concrete core wall |
| Length: | 1,500 feet |
| Height: | 38 feet |
| Top Width: | 24 feet |
| Side Slopes: | 2 horizontal on 1 vertical |
| Zoning: | None |
| Impervious core: | Concrete core wall |
| Cut-off | Steel sheet pile,depth unknown |
| Grout curtain: | None |

h. Diversion and Regulating Tunnel

| | |
|---|---|
| Type: | NA |
| Length: | NA |
| Closure: | NA |
| Access: | NA |
| Regulating Facilities: | NA |

i. Spillway

| | |
|---|---|
| Type: | Broad crested ogee sill |
| Length of weir: | 79 feet net |
| Crest elevation: | 94.33 MLS |
| Gates | None |
| U/S channel | None |
| D/S channel | Spillway chute channel 630-foot long by 38-foot wide |

j. Regulating Outlets

| | |
|---|---|
| Type: | Cast iron low level outlet, 48-in.dia. |
| Length: | Approximately 160 feet |
| Closure: | Two 36-inch diameter slide gate valves; one motor operated, the other hand operated |
| Access: | Gate accessible and housed in a gate house downstream of embankment |
| Regulating Facilities: | Regulation by partial opening of gate valve |

## SECTION 2

## 2. ENGINEERING DATA

### 2.1 Design

Available original design drawings have been provided by the owner (Drawings 2, 3 and 4). Drawings are also available for modifications made in 1937 and 1976. No design computations, soil borings, soil tests or other geotechnical data is available to assess the stability of the embankment properly. No information is available on the depth of the steel sheet pile cut-off under the concrete core wall, or its horizontal extent into the abutments. No information is given on the original plans as to the extent of the concrete core wall into the abutments. Information in the files of the New Jersey Department of Environmental Protection list the steel sheet pile cut-off as being 65-foot deep, but this could not be substantiated by any other source of information uncovered.

### 2.2 Construction

No records have been uncovered as to the construction history of the dam, except for a statement from the owner's representative that it was constructed by horsedrawn equipment.

### 2.3 Operation

No documents have been uncovered as to operating rules pertaining to the regulation of the reservoir. Letters in the files of the New Jersey Department of Environmental Protection pertain to complaints about high water levels in the reservoir. The reservoir is simply operated to capture the maximum amount of water from the Pascack Brook watershed. Hydrograph of several storm events were submitted by the Owner for use in preparing this report.

## 2.4 Evaluation

a. Availability

The availability of data is fair considering the age of the dam. Data needed to fully assess the safety of the dam includes:

1. Subsurface information at the dam site, including engineering properties and parameters.

2. Soil properties of the embankment.

3. Data on the phreatic line within the dam section at several cross section lines including the maximum section and at the seepage area in the left abutment area.

A check list of engineering construction and maintenance data is included in Appendix A.

b. Adequacy

At present the engineering data available is not sufficient to draw a conclusion on the stability of the earth embankment. The additional data listed above should be acquired for further assessment and analysis.

c. Validity

Although the original design drawings dating back to 1903 differ in some respects from the dam as currently constructed, such as in the details of the dam axis, at the spillway bridge and at the low level outlet line, there is no reason to believe that the bulk of information shown on these drawing is not substantially correct and usable. The later drawings relating to modifications are considered acurate.

# S E C T I O N 3

## 3. VISUAL INSPECTION

### 3.1 Findings

a. General

The visual inspection made of Woodcliff Lake Dam revealed that the dam and appurtenances were in serviceable condition but a program of further investigations and remedial work is required to assure its continued safety.

b. Dam

Construction plans indicate an earth embankment with a concrete core wall and sheet pile cut-off. Observations indicate that the embankment, at least downstream, is a well-graded sand and gravel. It is reasonable to assume, based on visual observations, that the foundation consists of the same type of cohesionless material to bedrock. The crest of the dam is a two-lane asphalt paved road. Longitudinal cracking in the pavement is not believed related to embankment movement. No significant deviations in vertical or horizontal alignment were apparent.

The embankment slopes are two on one and there are no signs of past or present downstream slope instability. Upstream slopes are protected by riprap and no problems were apparent above the water line. Downstream slopes were overgrown with brush and small trees. Several holes dug by burrowing animals were observed.

Seepage was observed in four locations just downstream of the embankment toe near the left abutment. The seepage combines to form a 2-foot wide rivulet carrying 5 to 10 gpm of clear water. At the time of the inspection, vegetation in the area left of the gate control house was indigenous to swampy areas. One observation well was located at the toe of the downstream embankment approximately 75 feet left of the gate control house. The level of water in the well was 1 ft. below ground surface.

c. Appurtenant Structures

• Spillway Chute Channel

No seepage was visible in the area of the concrete spillway chute channel. Severe erosion, however, was observed at the end of the spillway chute channel which occured as a result of the storm on November 8, 1977. According to the owner's engineering representative, repaving of the spillway chute slab in 1976 increased the discharge velocity. During the storm, the increased kinetic power of the discharging water, severely eroded the downstream channel banks for approximately 100 feet in length and 30 feet in width, cutting away the backfill behind the spillway chute wall for a distance of 15 feet upstream of the end of chute. The discharging water also tore away the steel sheet piling from the edge of the spillway chute concrete and displaced and bent it downstream. The spillway crest concrete and the spillway chute floor concrete is in acceptable to good condition. There is no cracking of the overlay concrete and all construction joints are in alignment. The chute walls are in acceptable condition, showing some minor surface deterioration. The jointing in walls is in good alignment.

• Spillway Bridge and Piers

The concrete piers are in acceptable condition with no significant cracking or deterioration observed. The spillway beams have been strengthened by the addition of cantilever support beams at the piers and brackets at the two abutment walls. The brackets and beams impede the clear spillway area somewhat. Additional soffit encasement concrete was observed on the upstream bridge basin of the left spillway channel opening. The bridge itself is in acceptable condition for light vehicular traffic.

• Low Level Outlet

The dam's low level outlet consists of a single 48-inch diameter cast iron pipe at invert elevation 63.1 MSL. The line is controlled by two

36-inch diameter gate valves and their associated 48-in. by 36-in. reducers. These two valves are installed back to back with the valve stems in the horizontal position. The valves are located in a small valve house at the toe of the embankment. The capacity of the low level outlet is estimated at 530 cfs at a normal pool elevation of 94.33.

The upstream valve is manually operated and is normally left in the open position. The downstream valve is motor operated and is used to control the flow through the line, providing water for use downstream and serving as an emergency drawdown for the reservoir. Operation of the valve could become a problem at higher tailwater elevations.

Both valves appeared to be in good condition. The packing glands were not leaking, and the 90 degree bevel gear reduction drives were well lubricated and appeared to be well maintained. The owner's representative stated that both valves are functional and are operated when necessary. At the time of the inspection, the motor operated valve had recently been opened to 25 percent (9 inches) opening, in order to provide downstream water for Pascack Brook, since the reservoir had fallen below the crest of the spillway. No records are available concerning the last complete inspection of the 48-inch line.

d. Reservoir Area

The major portion of the reservoir rim is gently sloped. No indications of instability were readily apparent in the remaining portions of the reservoir rim.

The reservoir was observed to feed into a small, shallow pond approximately 750 feet north of the dam axis from the left abutment. Total seepage was estimated to be about 5 to 10 gpm at the time of the inspection. Seepage water appeared to be clear and free of fine soil particles. Approximately 200 feet of soil lies between the pond and the reservoir.

Upon examining the surficial evidence, it is believed that the reservoir abutments and possibly the channel section are underlain by flacio-fluvial gravel and sands that mantle interbedded red sandstone and shale (Brunswick formation). Hummocky topography in gravel and sand deposits were observed downstream of the right abutment. A geologic map of the reservoir is appended to the end of this report as Plate 8.

e. Downstream Channel

The downstream channel has been severely eroded during the storm of November 8, 1977 as described above. The coarser scoured materials from the banks and from behind the spilway chute walls has been redepositied in Pascack Brook Channel some 75 feet downstream of the end of spillway channel. According to the Owner's engineering representative, the scour downstream of the end of the spillway chute channel is not deep.

## 3.2 Evaluation

The visual inspection showed that the following items could affect the safety of the dam.

1. Brush and trees covering the downstream slope could cause problems from the root system.

2. The immediate area of the downstream embankment to the left of the low level outlet gate house is overgrown with trees making convenient inspection of seepage difficult. Vegetation also exists on the right abutment, obscuring examination and surveillance efforts.

   Seepage in this area is thought to be significant. Seepage may be occurring through cracks or joints in the corewall or through or under the sheet piling.

3. Burrowing animals have established habitations in the downstream embankment.

4. While the erosion at the end of the spillway chute channel does not pose an immediate threat to the stability of the dam at this time, due to its distance from the embankment, the situation should nevertheless be speedily corrected.

5. The low level outlet passes through the embankment dam before it is valved at the downstream side, This design feature is considered a safety hazard.

The visual inspection check list is included in Appendix A.

Photographs taken during the site inspection are included in Appendix B.

## S E C T I O N 4

# 4. OPERATIONAL PROCEDURES

## 4.1 Procedures

Woodcliff Lake Dam is used to impound water on Pascack Brook for water supply uses. The strategy is to impound and store the maximum amount of water. As a result, an attempt is made to keep the reservoir as full as possible and to release reservoir waters in accordance with water supply needs at Oradell Dam on the Hackensack River, the main stream to which the Pascack Brook is tributary. The reservoir releases for water supply needs are routed downstream by way of the natural channel of Pascack Brook. During heavy rains, the low level outlet is opened to control the water level in the reservoir.

## 4.2 Maintenance of Dam

The dam has been maintained by making periodic inspections of its facilities. The reservoir is visited every hour throughout the year by a security patrol to control unauthorized entry into the fenced-off reservoir and spillway areas at the dam. Water levels are normally read daily, and on an hourly basis when rain exceed one inch within 24 hours. A precipitation gage is maintained and read in the reservoir area. The security patrol makes note of any unusual occurrences at the dam site and reports in to the Manager of Operations. There is an alarm on the low level outlet gate house tied into the security patrol system to provide an alert in case of attempted tampering with the gate valve controls.
The dam is visited once a year by the Hackensack Water Company's engineering staff for an on-the-ground assessment of its facilities.
The Chief Engineer keeps a written memorandum of the inspection in his files.

### 4.3 Maintenance of Operating Facilities

The low level outlet gate valve opening is adjusted in accordance with the water needs at Oradell Dam and the minimum discharges desired in Pascack Brook in the reach between the dam and the confluence with the Hackensack River. Maintenance of the gate valves is made on a periodic basis in conjunction with visits to adjust the valve opening.

### 4.4 Description of Warning System in Effect

There is no fixed procedure for warning downstream residents in case of an emergency. The security patrol is in radio contact with the Hackensack Water Company headquarters and could respond to emergency situations in a reasonably short time.

### 4.5 Evaluation

Surveillance and maintenance is in the hands of an experienced staff working for a major private water supply company. The Hackensack Water Company has its own engineering staff and has shown an active interest in maintaining its facilities in a serviceable condition as is evidenced by its recent repairs to the spillway chute channel slab. The company should formalize its maintenance and inspection program for proper documentation, in line with the increased public interest in dam safety. A program for the control of vegetation growing on the downstream slope of the dam and for 35 to 50 feet downstream of the toe of slope should be initiated. A program for the control and elimination of burrowing animals inhabiting the downstream embankment slope should also be initiated.

## SECTION 5

## 5. HYDRAULIC/HYDROLOGIC

### 5.1 Evaluation of Features

a. Design Data

The Woodcliff Lake Dam impounds about 2,750 acre-feet of water in the reservoir at normal storage capacity. The watershed area above the Woodcliff Lake Dam is 19.4 square miles. The orientation of the watershed is from north to south with the lower one-third of the drainage area lying in the State of New Jersey and the upper two-thirds area in the State of New York. Length of Pascack Brook from the headwater of the Woodcliff Lake reservoir to the watershed divide is approximately 10.2 miles. A drainage map of the watershed of the Woodcliff Lake Dam is given in Plate 1, Appendix D.

The evaluation of the hydraulic and hydrologic features of the Woodcliff Lake Dam was based on criteria set forth in the Corps "Guidelines", Section 4.3 and additional guidance provided by the Philadelphia District Corps of Engineers. The Probable Maximum Flood (PMF) was calculated from the Probable Maximum Precipitation (PMP) using Hydrometeorological Report #33 with standard reduction factors. The Snyder Method was used for deriving the unit hydrograph with $C_t$ = 4.3 and 640 $C_p$ = 530.

Initial infiltration loss rates were applied using SCS procedures to the Probable Maximum Storm rainfall to obtain rainfall excess. The rainfall excess was then applied to the unit hydrograph to obtain the PMF hydrograph, utilizing computer program HEC-1. The computed peak discharge of PMF and one half of the PMF are 13,805 cfs and 6,902 cfs respectively.

These inflow hydrographs were routed through the reservoir by the modified Puls method utilizing computer program HEC-1. The peak outflow discharges for the PMF and one half of PMF are 13,762 cfs and 6,885 cfs respectively. Both the PMF and one half of the PMF result in overtopping of the dam.

The stage-outflow relation for the spillway and the reservoir stage-capacity data were based upon information provided by the Hackensack Water Company. The spillway rating curve and the reservoir capacity curves are presented in Plates 2 and 3 of Appendix D respectively.

b. Experience Data

Records of daily reservoir stage level are maintained since the reservoir was in operation. The reservoir water level usually maintains at lower than elevation 94.33 except during floods. There are no records indicating that the reservoir water surface elevation went over the dam crest at any time.

c. Visual Observations

It was noted the automatic water level recorder located on the left shore of the reservoir was not functioning and all the water level readings were taken manually. There is no evidence of excessive sedimentation due to recent developments in the drainage basin which could cause a sudden increase in sediment load which may pose danger to the dam. Detrimental scour and severe erosion were observed at the end of the spillway discharge channel which occurred as a result of the storm on November 8, 1977.

d. Overtopping Potential

As indicated in item a., both the PMF and the one half of the PMF, when routed through the Woodcliff Lake reservoir, result in overtopping the dam. The PMF and one half PMF overtopped the dam by 1.10 feet and 0.3 feet respectively.

The spillway is capable of passing a flood equal to about 31 percent of the PMF without overtopping the dam. Since PMF is the Spillway Design Flood (SDF) for this dam according to the recommended "Guidelines" for Inspection of Dams by the Corps, the spillway capacity of the Woodcliff Lake Dam is considered inadequate.

e. Reservoir Drawdown

The reservoir drawdown below the spillway crest elevation 94.33 is accomplished by permitting discharge through the 48-inch outlet pipe with invert elevation 63.08. Assuming drawdown to the top of the pipe, elevation 67.0 results in a maximum head differential of 27.33 feet. Assuming a constant inflow of 39 cfs (2 cfs/acre), the drawdown can be accomplished in 5 days and 14 hours. Assuming no inflow into the reservoir, the drawdown time is reduced to 4 days and 12 hours.

## SECTION 6

### 6.1 STRUCTURAL STABILITY

a. Visual Observations

There are no signs of embankment sloughing, local slides or slumps on the downstream side. The upstream side of the embankment was almost completely under water and was not available for visual inspection. The leakage and seepage in the left abutment, described in Section 3.1 - b. have not been monitored by the owner and no information was uncovered concerning their age or flow rate.

The spillway chute slab exhibits no visual evidence of cracking, slide failure, undermining or misalignment, in spite of the washout caused by the storm of November 8, 1977 and described in Section 1.2.

b. Design and Construction Data

No design computations were uncovered during the report preparation phase. No embankment or foundation soil parameters are available for carrying out a conventional stability analysis on the embankment. No construction data or specifications relating to the degree of embankment compaction are available for use in the stability analysis.

A stability analysis was made as part of this report on the downstream slope assuming that the embankment material had the following properties: angle of internal friction $\phi$ = 30 degrees, unit weight of embankment 130 pounds per cubic feet, and that the embankment downstream of the core wall was dry. The analysis showed that the downstream slope was stable under these conditions. The slope would be unstable if the downstream embankment slope were subject to high phreatic water levels, such as could exist in the seeping left abutment section. The stability of the section at the right abutment was not checked for the location of the phreatic line. It is recommended that embankment and

subsoil engineering parameters be acquired together with phreatic levels at sections exhibiting seepage and at another section not exhibiting seepage so that stability computation can be carried out to verify the preliminary assumptions made.

c. Operating Records

No operating records are available relating to the stability of the dam. Water levels in the one observation well discovered at the site have not been recorded. According to the owner's engineering officials, the embankment has served satisfactorily since 1905, its construction date.

d. Post Construction Changes

There have been no post construction changes affecting the stability of the embankment.

e. Seismic Stability

In general, projects located in Seismic Zone 0, 1 and 2 may be assumed to present no hazard from earthquake, provided the static stability conditions are satisfactory and conventional safety margins exist.

S E C T I O N  7

## 7. ASSESSMENT / REMEDIAL MEASURES

### 7.1 Dam Assessment

a. Safety

The dam has been inspected visually and a review has been made of the available engineering data. This assessment is subject to the limitations inherent in the visual inspection procedures stipulated by the Corps of Engineers for Phase I Report.

The spillway capacity has been found to be inadequate. The routed PMF will top the dam crest by 1.0 foot and the routed one half PMF will top the dam by 0.3 foot. Overtopping of the embankment will carry with it a high risk of total failure of the embankment by erosive action of the overtopping water.

The spillway capacity has been determined by Corps of Engineers screening criteria and should be determined by the owner using more accurate and sophisticated methods and procedures.

The following actions are recommended:

1. All brush and trees should be removed from the downstream slope to avoid problems which may develop from their roots. The embankment should then be seeded to develop a growth of grass for surface erosion protection.

2. An area should be cleared in the immediate area of the downstream embankment on both sides of the low level outlet gate house to facilitate inspection. The cleared area should extend 35 to 50 feet

downstream of the toe line of the embankment, regraded and reseeded as required. This area should be maintained under a cut vegetative cover. The seepage in this area should be channelized, measured and monitored, and correlated to rainfall and reservoir levels.

3. Burrowing aninals should be destroyed and their holes backfilled as best as possible, wherever they exist in the downstream embankment or at the area below the toe line.

4. Piezometers or observation wells should be installed in the embankment near the left abutment to determine the paths of the seepage observed. Seepage may be occurring through cracks or joints in the corewall or through or under the sheet piling. Once the location of the phreatic surface in the embankment is determined, then effective corrective measures can be considered and undertaken. Piezometers should also be installed in the vicinity of the gate house where there are no signs of leakage to provide a comparison with an apparently satisfactory section.

No assessment of the safety of the embankment can be made at this time pending acquisition of embankment and foundation material engineering properties and determination of phreatic levels in the downstream part of the abutment.

5. While the erosion at the end of the spillway chute does not pose an immediate threat to the stability of the dam at this time, due to its distance from the embankment, the situation should nevertheless be speedily corrected. The banks should be restored to their original contours and protected by stone. Studies should be made to determine the best way to dissipate the increased kinetic energy of the spillway chute water caused by lower friction losses on the repaved chute slab. The eroded materials should be removed from the stream channel and the channel regraded as required to produce a smooth water level surface during high stream stages.

6. The low level outlet valving should be moved to the upstream side of the dam's core wall. A study should be undertaken to determine the best way to accomplish this work and the approved plan implemented.

7. While the pond to the north of the left abutment did not appear to be a threat to the safety of the reservoir at the time of the inspection, periodic inspections of the area are recommneded, to verify that the situation with respect to seepage is stable.

8. The timely repair of the automatic water level recorder in the gaging station is recommended.

b. Adequacy of Information

No data on the properties of the embankment material exists for assessment of the stability of the dam. A program for the acquisition of this data is recommended together with similar data pertaining to the underlying soil formation. A program to determine the location of the phreatic line along the downstream half of the dam is also recommended.

c. Urgency

It is recommended that the investigations of the engineering properties of the embankment materials and the location of the phreatic line be completed within six months. The maintenance items listed in Section 3.2 should be completed within one calendar year. A report on the alternatives for remedying the left abutment seepage should be completed within one calendar year. A report on the possibility of adding auxiliary spillway capacity should be completed within one calendar year. A report on shifting the low level outlet valving to the upstream side of the core wall should be completed within 12 months, and the modification completed within 18 months.

d. Necessity for Additional Investigations

Based on the findings listed in Section 7.1 - a., it is recommended that further investigations be authorized.

## 7.2 Remedial Measures

a. Alternatives

The remedial actions summarized in Section 7.1 - a., are recommended for implementation.

The course of action to be taken in the matter of the seepage emanating from the downstream toe of embankment slope depends upon the analysis of phreatic line geometry. Possible alternatives include:

1. Lowering the phreatic line by means of drains.

2. Regrading the area at downstream of the embankment toe.

3. Adding berm materials.

4. No action.

Possible alternatives for increasing the spillway capacity of the dam include:

1. Development of an auxiliary spillway on the right abutment to bring the total spillway capacity to up to at least one half PMF and possibly higher.

2. Development of a new and possibly gated service spillway which combined with the present spillway would pass the PMF. The present service spillway would serve as an auxiliary spillway.

3. Regulation of the reservoir water surface to some specified level below the present weir crest to allow for routing of a higher inflow than presently possible with the pool at elevation 94.33.

4. Removal of bridge piers and construction of a new bridge.

5. Consideration should be given to the use of energy dissipation at the bottom of the spillway for all spillway augmentation schemes.

6. A combination of any of the three alternatives.

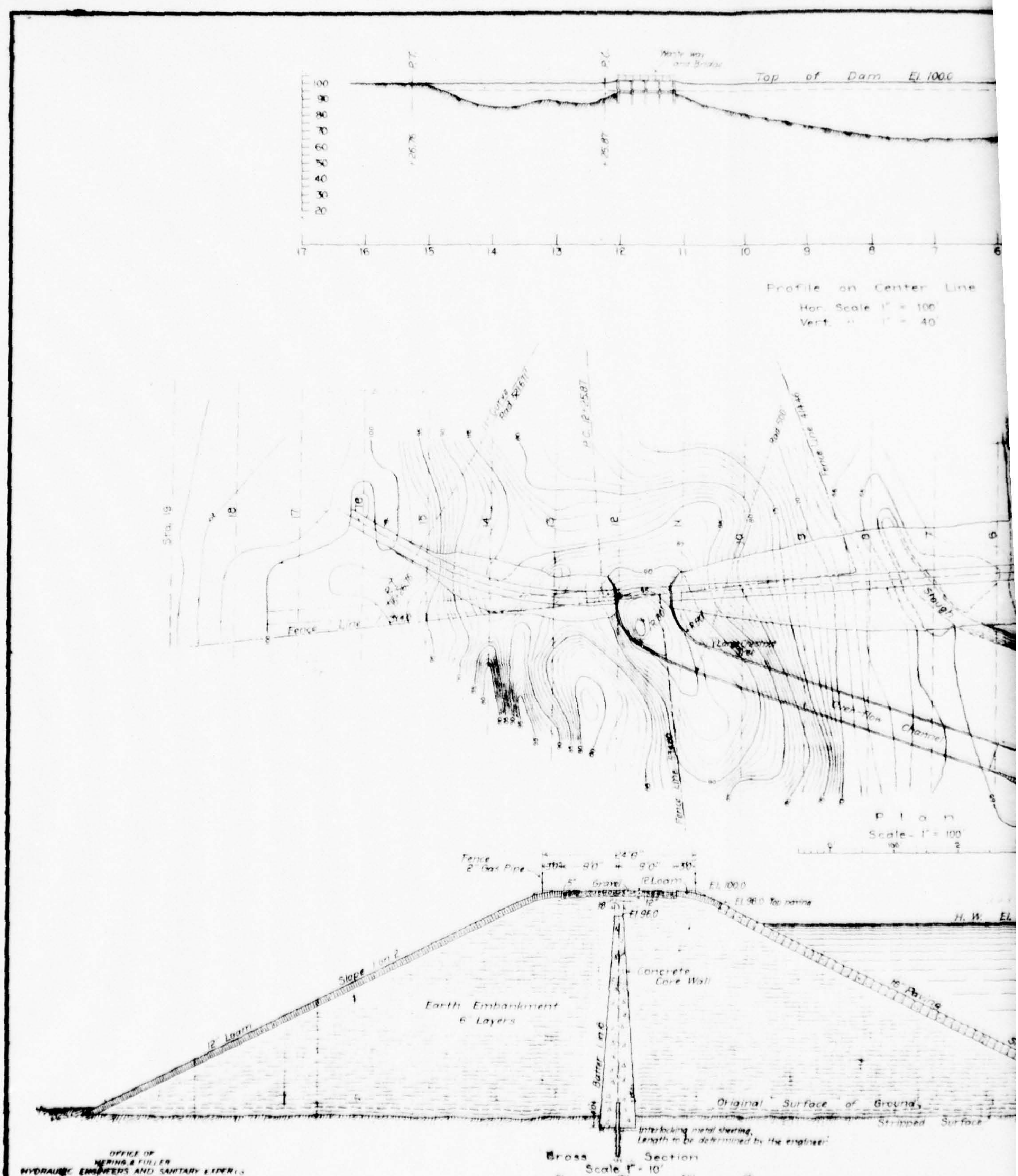
b. O & M Procedures

The owner should upgrade his O & M procedures by issuing a manual and check list for recommended procedures. The inspection and maintenance visits should be logged and documented. A communication channel should be maintained between the owner and civil authorities in the downstream community of Hillsdale in case of accident, high reservoir inflow conditions or a dam operating failure causing high water stages downstream.

PLATES


VICINITY MAP

DWG. NO. I

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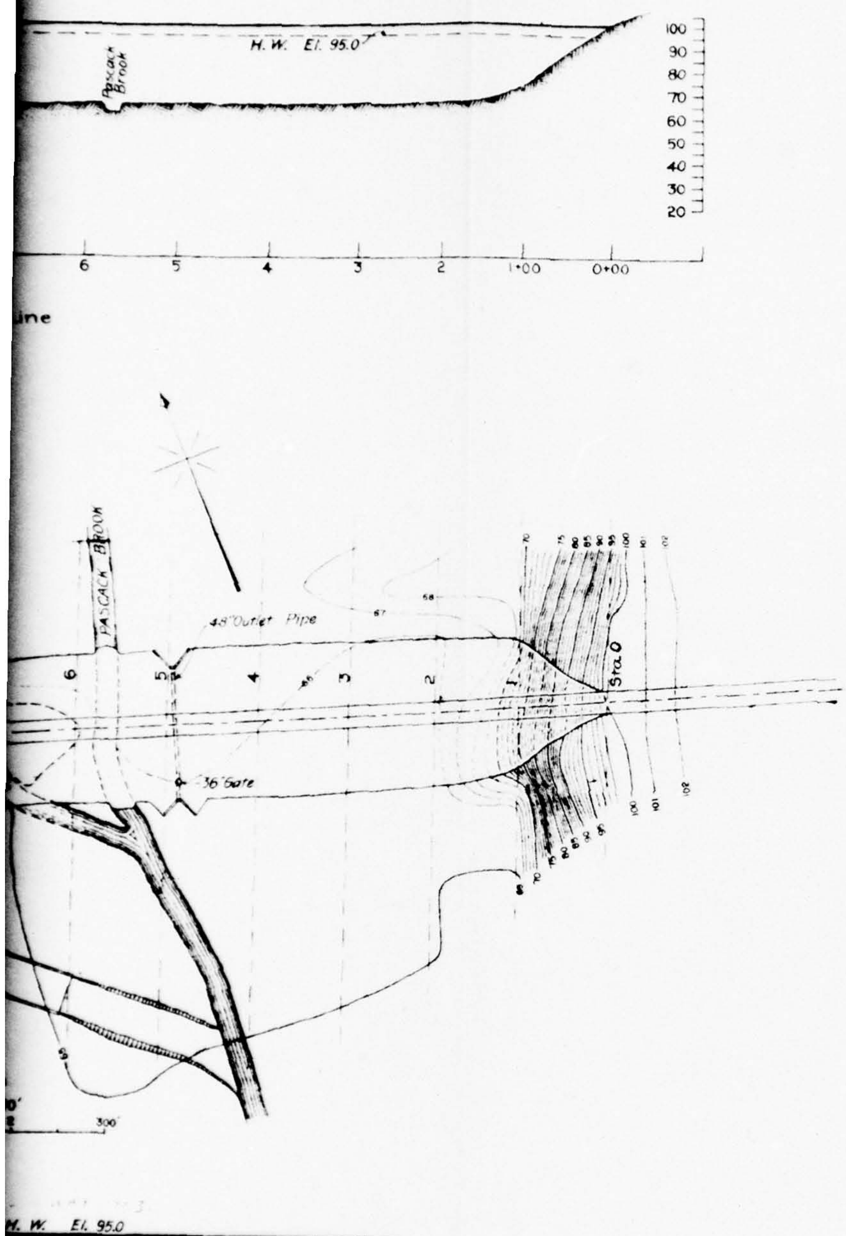
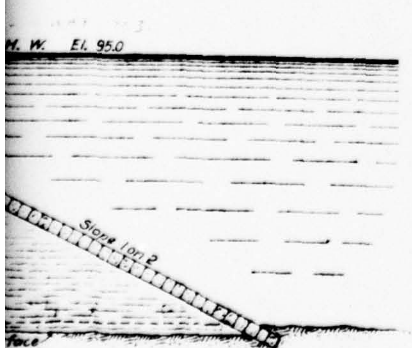
170 BROADWAY
NEW YORK



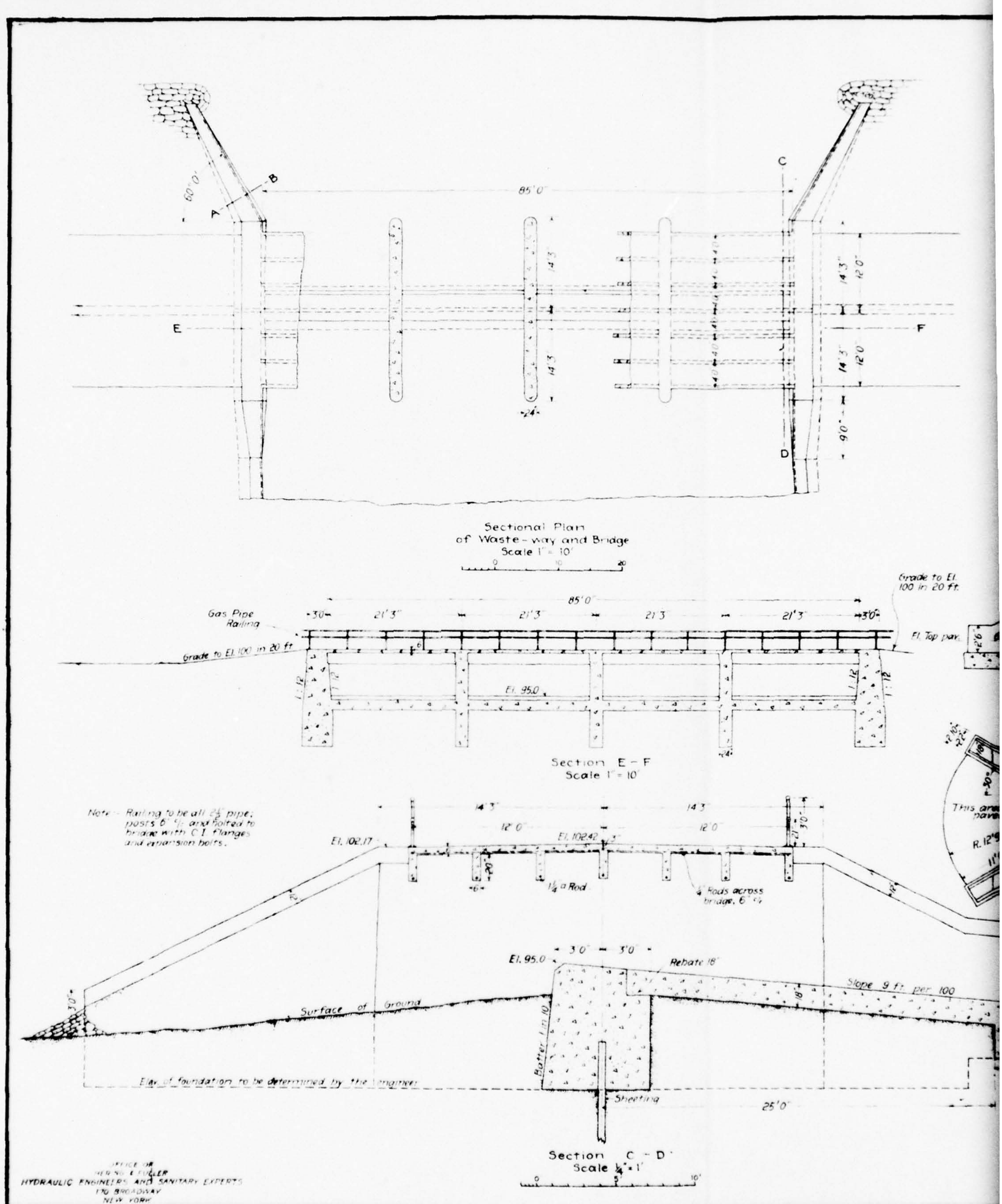

WOODCLIFF LAKE
DWG. NO. 2

Dwg. # 1134/46 (251)

HACKENSACK WATER Co.
HILLSDALE RESERVOIR
PLAN, PROFILE AND SECTION OF DAM
SCALES AS INDICATED
AUG. 1903

Approved Hering & Fuller

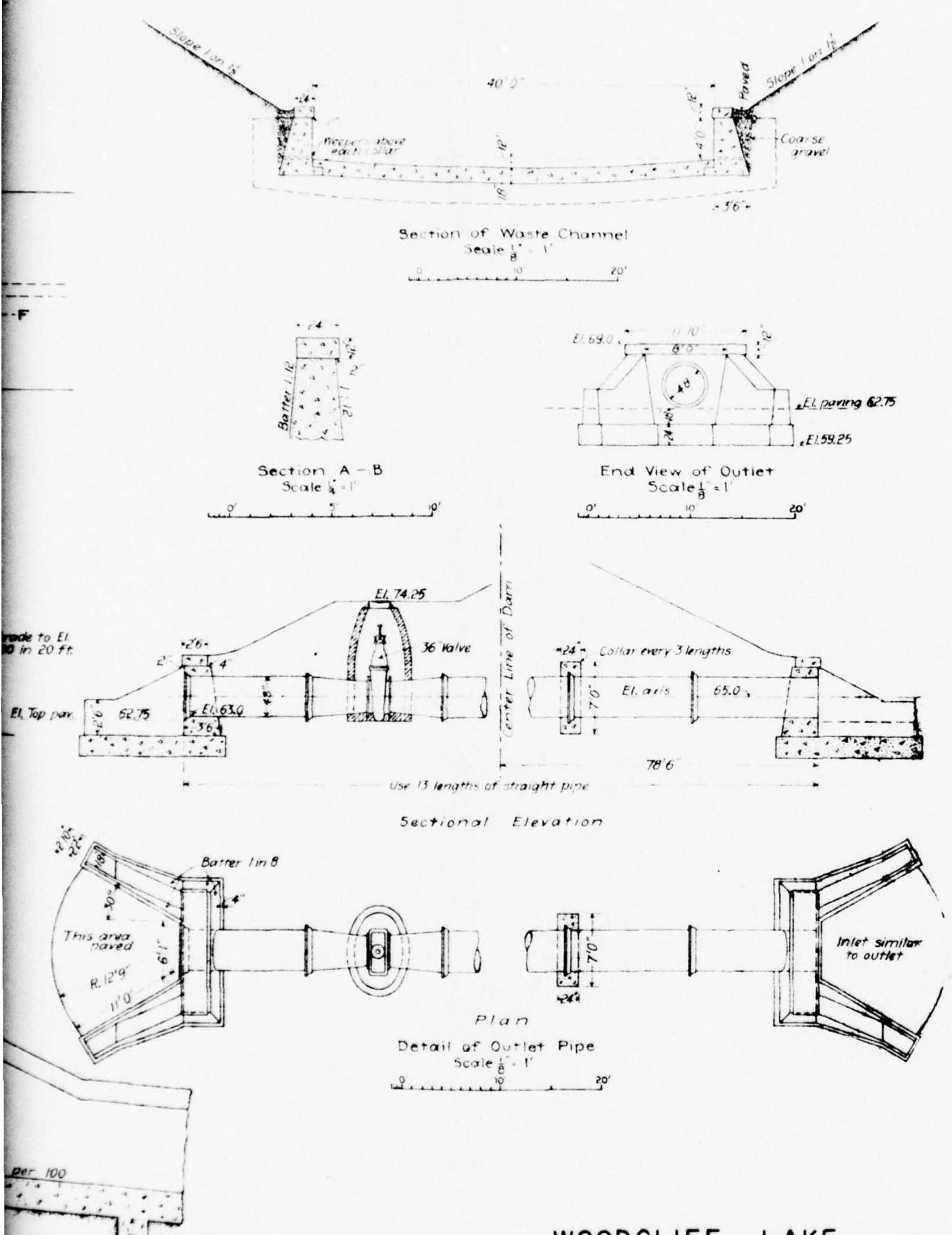
Sheet No. 2




Sectional Plan of Waste-way and Bridge
Scale 1" = 10'

Section E - F
Scale 1" = 10'

Section C - D
Scale ¼" = 1'




# WOODCLIFF LAKE

## DWG. NO. 3

Dwg. No 113-1/47 (251)

HACKENSACK WATER Co

HILLSDALE RESERVOIR

WASTE-WAY AND OUTLET PIPE

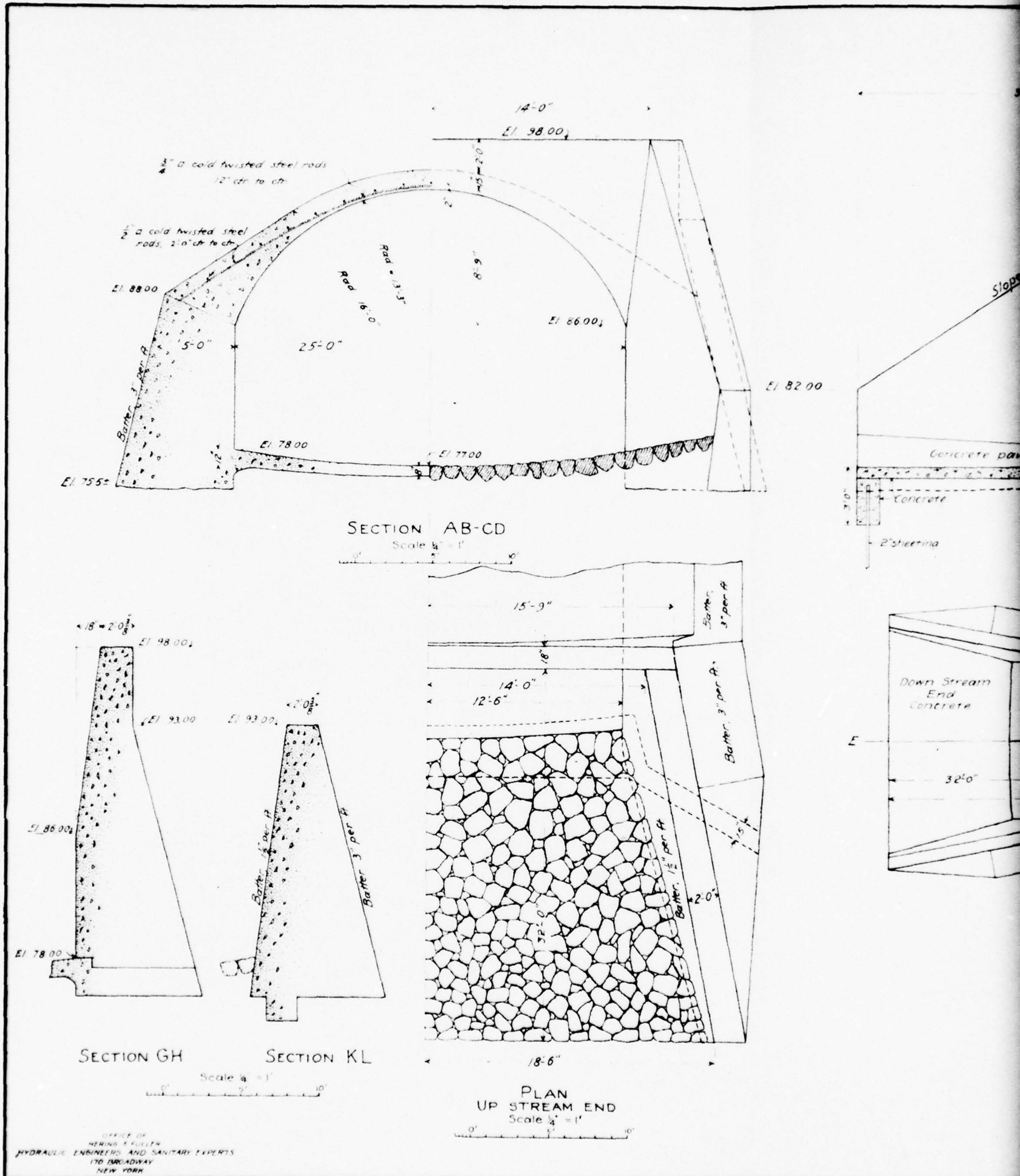
SCALES AS INDICATED

AUG. 1903

Approved I. Hering & Fuller

Sheet No. 3

2a



14'-0"
El. 98.00
3/4" ø cold twisted steel rods 12" ctr. to ctr.
1/2" ø cold twisted steel rods, 2'-0" ctr. to ctr.
Rad. = 13'-3"
Rad. 16'-0"
8'-9"
El. 88.00
El. 86.00
5'-0"
25'-0"
Batter 3" per ft.
El. 82.00
El. 78.00
El. 77.00
El. 75.5±
Slope
Concrete pave
Concrete
3'-0"
2" sheeting
SECTION AB-CD
Scale 1/4" = 1'
15'-9"
Batter 3" per ft.
18"
14'-0"
12'-6"
Batter 3" per ft.
15"
Batter 1 1/2" per ft.
2'-0"
32'-0"
18'-6"
Down Stream End Concrete
E
32'-0"
18" = 2'-0 3/8"
El. 98.00
El. 93.00
2'-0 3/8"
El. 93.00
El. 86.00
Batter 1/2" per ft.
Batter 3" per ft.
El. 78.00
SECTION GH
SECTION KL
Scale 1/4" = 1'
PLAN
UP STREAM END
Scale 1/4" = 1'
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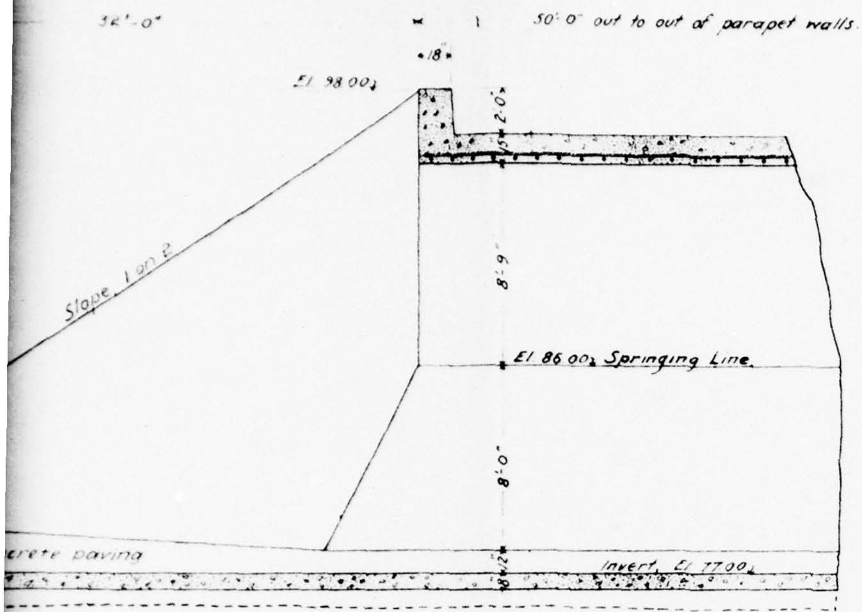
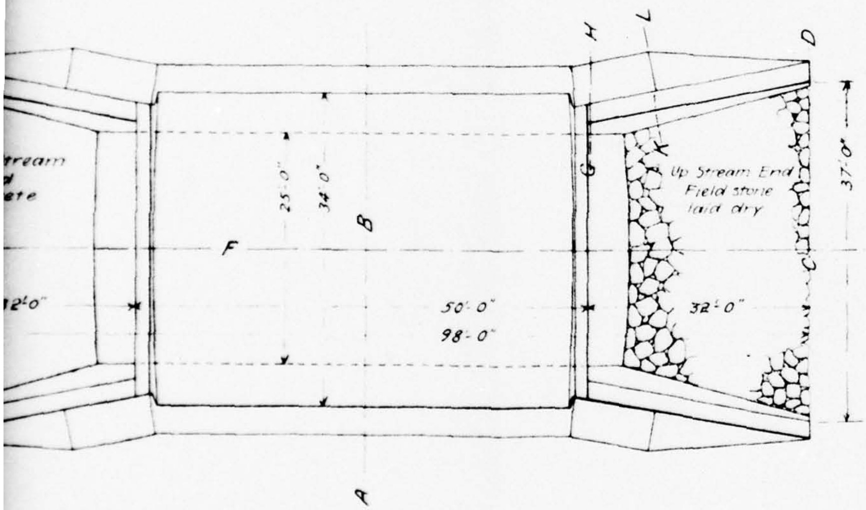
NEW YORK




SECTION EF

Scale 1/4" = 1'




GENERAL PLAN

Scale 1" = 10'

**WOODCLIFF LAKE**

Dwg 113-1/45 (251)

**DWG. NO. 4**

HACKENSACK WATER C°

HILLSDALE RESERVOIR

CONCRETE ARCH BRIDGE FOR ROAD CROSSING

SCALES AS INDICATED

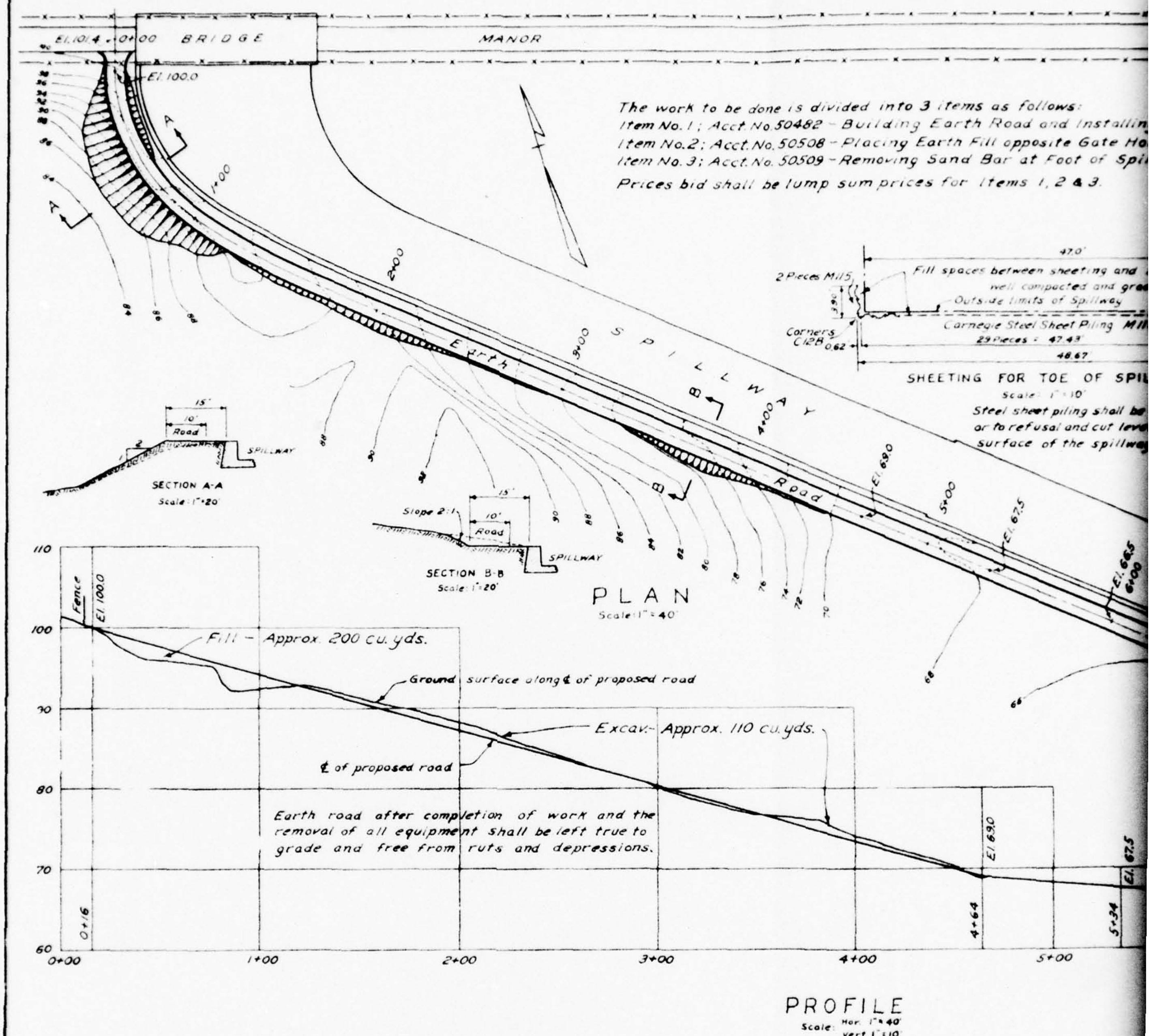
MARCH 1904

Approved

Sheet No. 4

2

The work to be done is divided into 3 items as follows:
Item No. 1; Acct. No. 50482 – Building Earth Road and Installin
Item No. 2; Acct. No. 50508 – Placing Earth Fill opposite Gate Ho
Item No. 3; Acct. No. 50509 – Removing Sand Bar at Foot of Spi
Prices bid shall be lump sum prices for Items 1, 2 & 3.




## SPECIFICATIONS

The extent of the work as shown is approximate and may be varied within reasonable limits without affecting prices bid to suit actual requirements.

The use of existing structures for any purpose in construction will not be permitted unless full consent and approval have been obtained from the Hydraulic Engineer of the Hackensack Water Co. Vehicles using the bridge across the spillway will be restricted to a maximum total load of 5 tons, including weight of vehicle.

Sanitary conveniences must be provided and strict regulations shall be issued and enforced for their use.

Excavated material shall be spread on adjacent low lands, in a manner which will permit water to run off and not form pools.

Fill can be obtained from the Company's property just southeast of the dam.

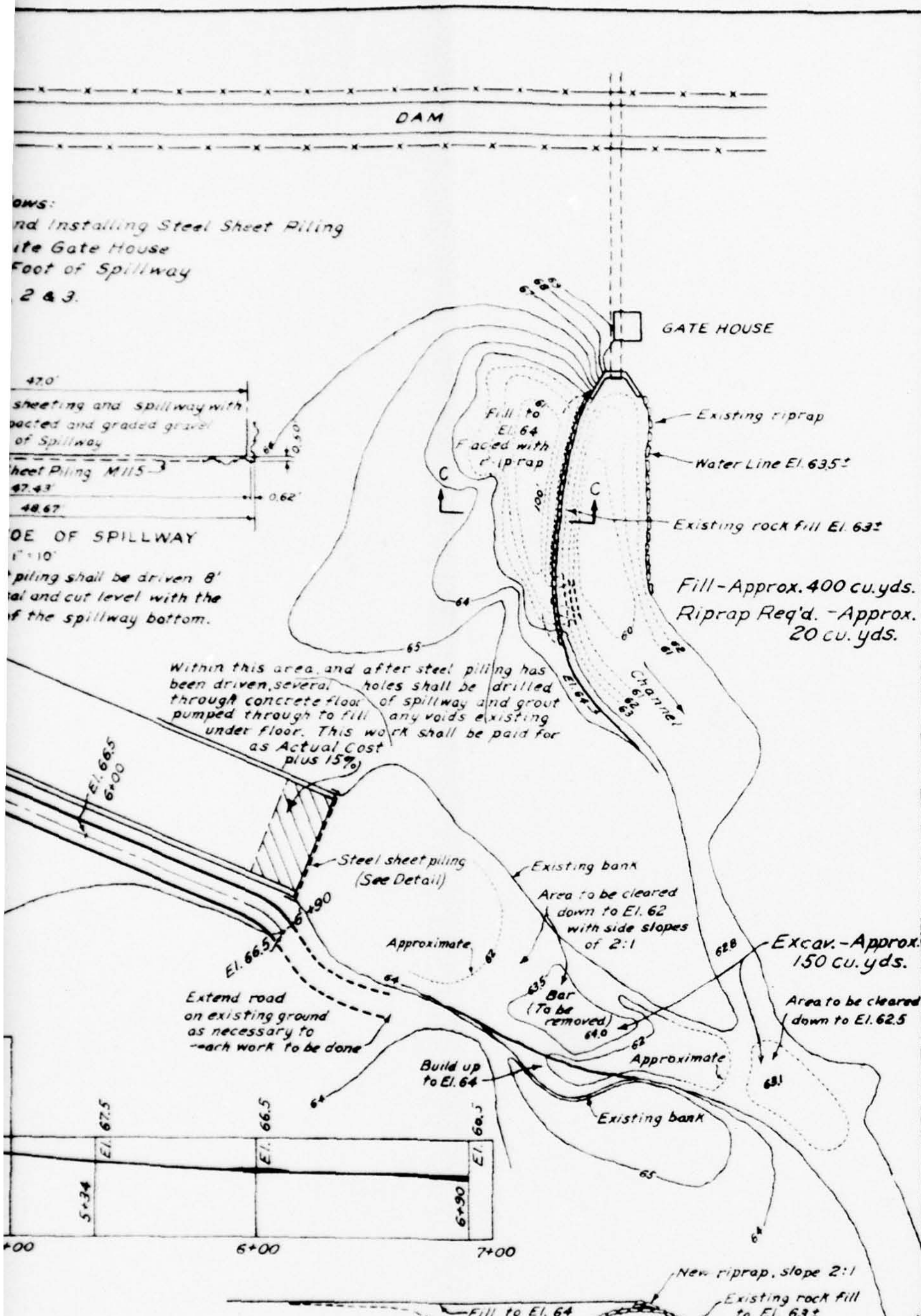
The site of work including borrow pit, shall be left in a good condition upon completion of the work.

All conditions, procedure and terms relat of the work to its completion shall be subject and approval of the Hydraulic Engineer.

The quantities of earth excavation and approximate only, but will not vary materiall amount of work to be done.

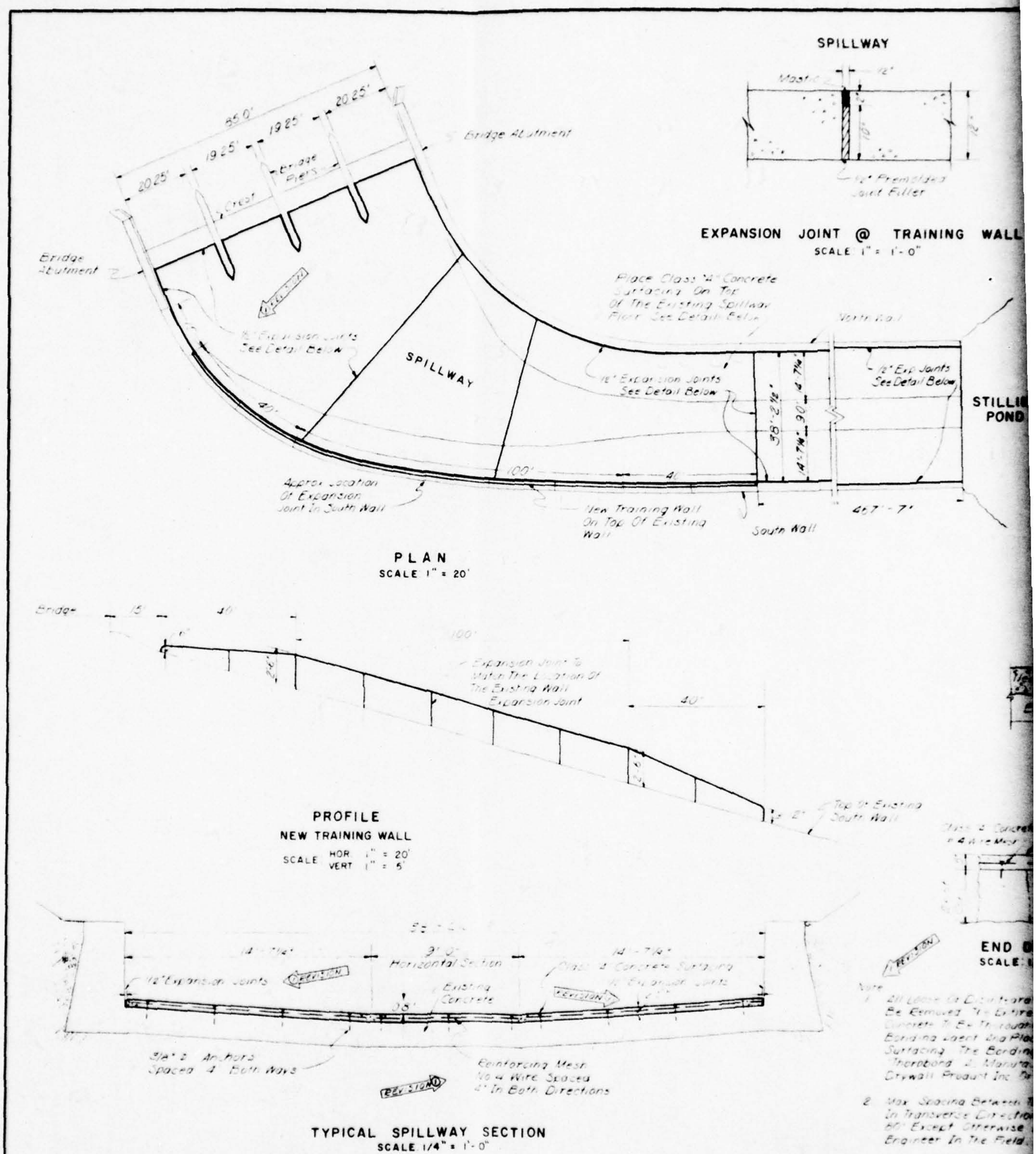
The prices bid shall be lump sum prices ing all materials, plant equipment and tool work hereon shown to be done.

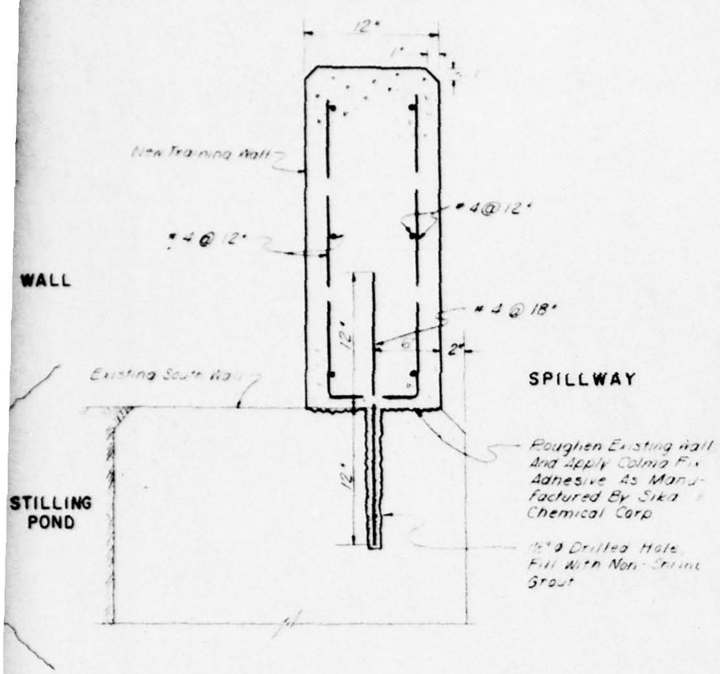
IMPERIAL TRACING CLOTH



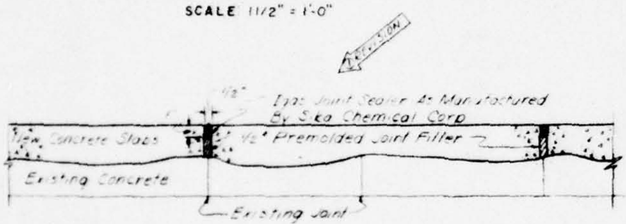
DAM
...ows:
...nd Installing Steel Sheet Piling
...ite Gate House
...Foot of Spillway
..., 2 & 3.
GATE HOUSE
47.0'
...sheeting and spillway with
...pacted and graded gravel
...of Spillway
...Sheet Piling M115
47.43'
48.67'
0.62'
...OE OF SPILLWAY
...piling shall be driven 8'
...al and cut level with the
...f the spillway bottom.
Fill to El. 64 Faced with riprap
Existing riprap
Water Line El. 63.5±
Existing rock fill El. 63±
Fill - Approx. 400 cu. yds.
Riprap Req'd. - Approx. 20 cu. yds.
Channel
Within this area, and after steel piling has been driven, several holes shall be drilled through concrete floor of spillway and grout pumped through to fill any voids existing under floor. This work shall be paid for as Actual Cost plus 15%.
El. 66.5
6+00
Steel sheet piling (See Detail)
Existing bank
Area to be cleared down to El. 62 with side slopes of 2:1
6+90
El. 66.5
Approximate
Exav. - Approx. 150 cu. yds.
Bar (To be removed)
Area to be cleared down to El. 62.5
Extend road on existing ground as necessary to reach work to be done
Build up to El. 64
Approximate
Existing bank
El. 67.5
El. 66.5
El. 66.5
5+34
6+90
6+00
7+00
New riprap, slope 2:1
Existing rock fill to El. 63±
Fill to El. 64
Existing approximate ground surface
SECTION C-C
Scale: 1"=10'
...e work.
...terms relative to the prosecution
...be subjected to the satisfaction
...ngineer.
...vation and fill given hereon are
...y materially from the actual
...um prices complete for furnish-
...t and tools for performing the
DWG. NO. 5
DRAWING NO 113-1 / 49 P
HACKENSACK WATER CO.
WEEHAWKEN, N. J.
WOODCLIFF LAKE RESERVOIR IMPROVEMENTS TO SPILLWAY
SCALE As Shown
DATE 5-18-37.
ACCOUNT NO. 50482
INVESTIGATION NO —
EXTENSION NO —
DRAWN BY Peter
CHECKED BY
APPROVED BY


2

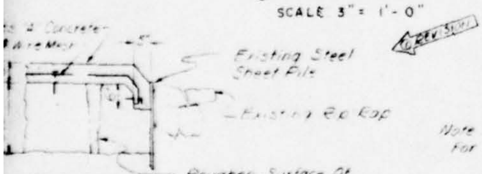

SPILLWAY
Mastic
1/2"
10"
12"
1/2" Premolded Joint Filler
EXPANSION JOINT @ TRAINING WALL
SCALE 1" = 1'-0"
85.0'
20.25'
19.25'
19.25'
20.25'
Bridge Abutment
Bridge Piers
Crest
Bridge Abutment
Place Class "A" Concrete Surfacing On Top Of The Existing Spillway Floor See Detail Below
North Wall
1/2" Expansion Joints See Detail Below
SPILLWAY
1/2" Expansion Joints See Detail Below
1/2" Exp Joints See Detail Below
STILLI
POND
38'-2 1/2"
30'
4'-7 1/4"
4'-7 1/4"
40'
100'
40'
Approx Location Of Expansion Joint In South Wall
New Training Wall On Top Of Existing Wall
South Wall
467'-7"
PLAN
SCALE 1" = 20'
Bridge
15'
40'
100'
Expansion Joint To Match The Location Of The Existing Wall Expansion Joint
40'
Top Of Existing South Wall
PROFILE
NEW TRAINING WALL
SCALE HOR 1" = 20'
VERT 1" = 5'
14'-7 1/4"
9'-0"
Horizontal Section
14'-7 1/4"
1/2" Expansion Joints
Existing Concrete
Class "A" Concrete Surfacing
0.8'
3/8" Anchors Spaced 4' Both Ways
Reinforcing Mesh No 4 Wire Spaced 4" In Both Directions
REVISION
TYPICAL SPILLWAY SECTION
SCALE 1/4" = 1'-0"
END
SCALE
Note
Be Removed
Concrete
Bonding Agent And Place
Surfacing The Bonding
"Thorobond"
Drywall Product Inc
2. Max Spacing Between
In Transverse Direction
60' Except Otherwise
Engineer In The Field
Revision 10/7/




TYPICAL SECTION
NEW TRAINING WALL
SCALE 1 1/2" = 1'-0"




EXPANSION JOINT DETAIL
@ SPILLWAY FLOOR
SCALE 3" = 1'-0"




END DETAIL
SCALE 1/2" = 1'-0"

Note
For Crest Detail See Dwg No 1

... Disintegrated Concrete To ... The Entire Surface Of Existing ... Thoroughly Before Applying ... and Placing Class "A" Concrete ... The Bonding Agent Shall Be ... As Manufactured By Standard ... Inc. Or Approved Equal

... Between The Expansion Joints ... Direction Shall Not Exceed ... Otherwise Determined By The ... The Field

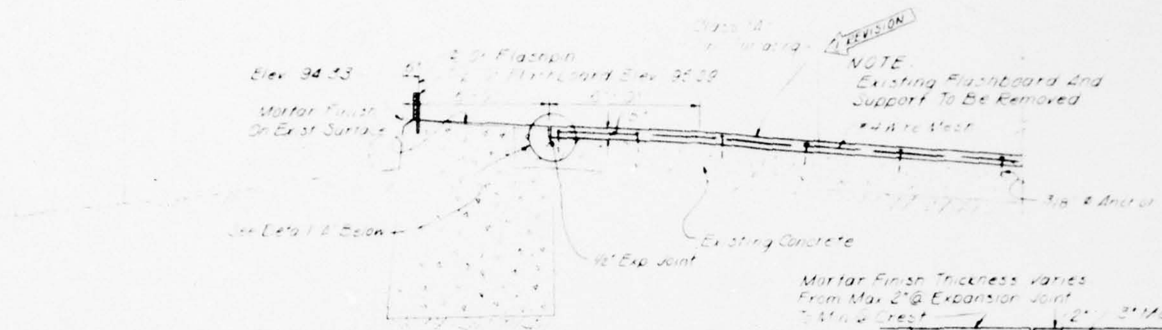
10/7/76

DWG. NO. 6

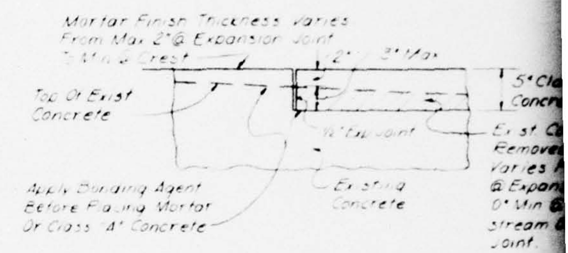
DRAWING NO. $\frac{113-1}{76}$ - 2

| HACKENSACK WATER CO. WEEHAWKEN, N. J. | | |
|---|---|---|
| IMPROVEMENTS TO WOODCLIFF LAKE SPILLWAY HILLSDALE, N. J. NEW TRAINING WALL AND SPILLWAY FLOOR REPAIR | | |
| SCALE: AS SHOWN | | DATE: AUG. 1976 |
| BUDGET ITEM NO. | INVESTIGATION NO. | EXTENSION NO. |
| DRAWN BY | CHECKED BY | APPROVED BY |

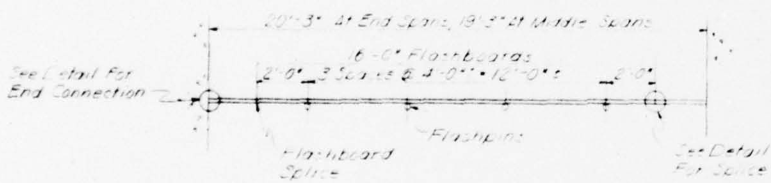
2



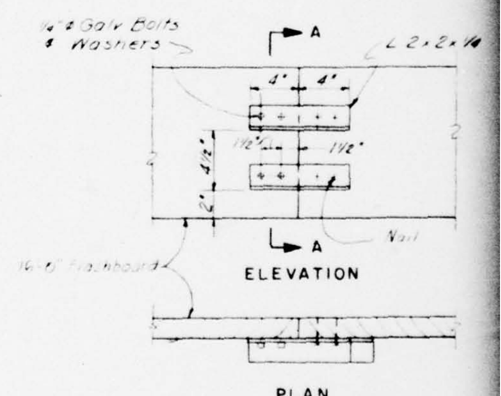

SECTION THRU SPILLWAY CREST
SCALE: 1/4" = 1'-0"



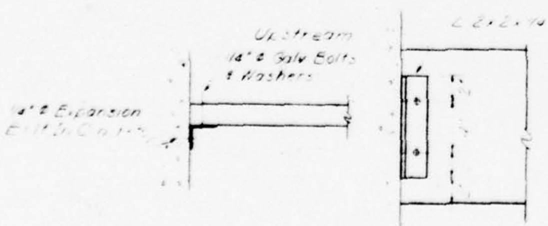

DETAIL "A"




PLAN OF FLASHBOARD CENTERING
SCALE: 1/4" = 1'-0"

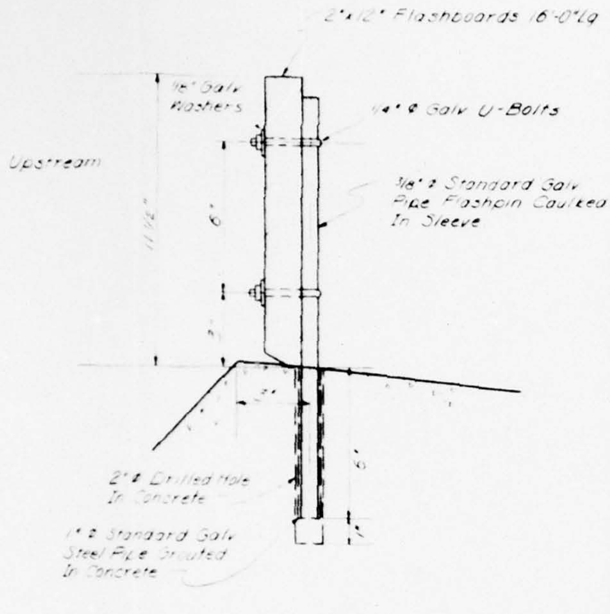


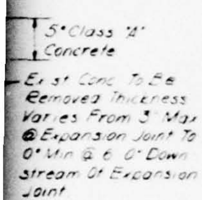

DETAIL OF FLASHBOARD
SCALE: 1 1/4" = 1'-0"




DETAIL OF END CONNECTIONS
SCALE: 1 1/2" = 1'-0"

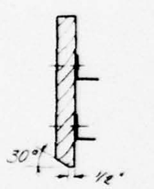
Revision ①




DETAIL OF FLASHPIN

SCALE 3" = 1'-0"


SECTION A - A

BOARD SPLICE

= 1'-0"

DWG. NO. 7

DRAWING NO. 113-1/76 - 1

HACKENSACK WATER CO.
WEEHAWKEN, N. J.

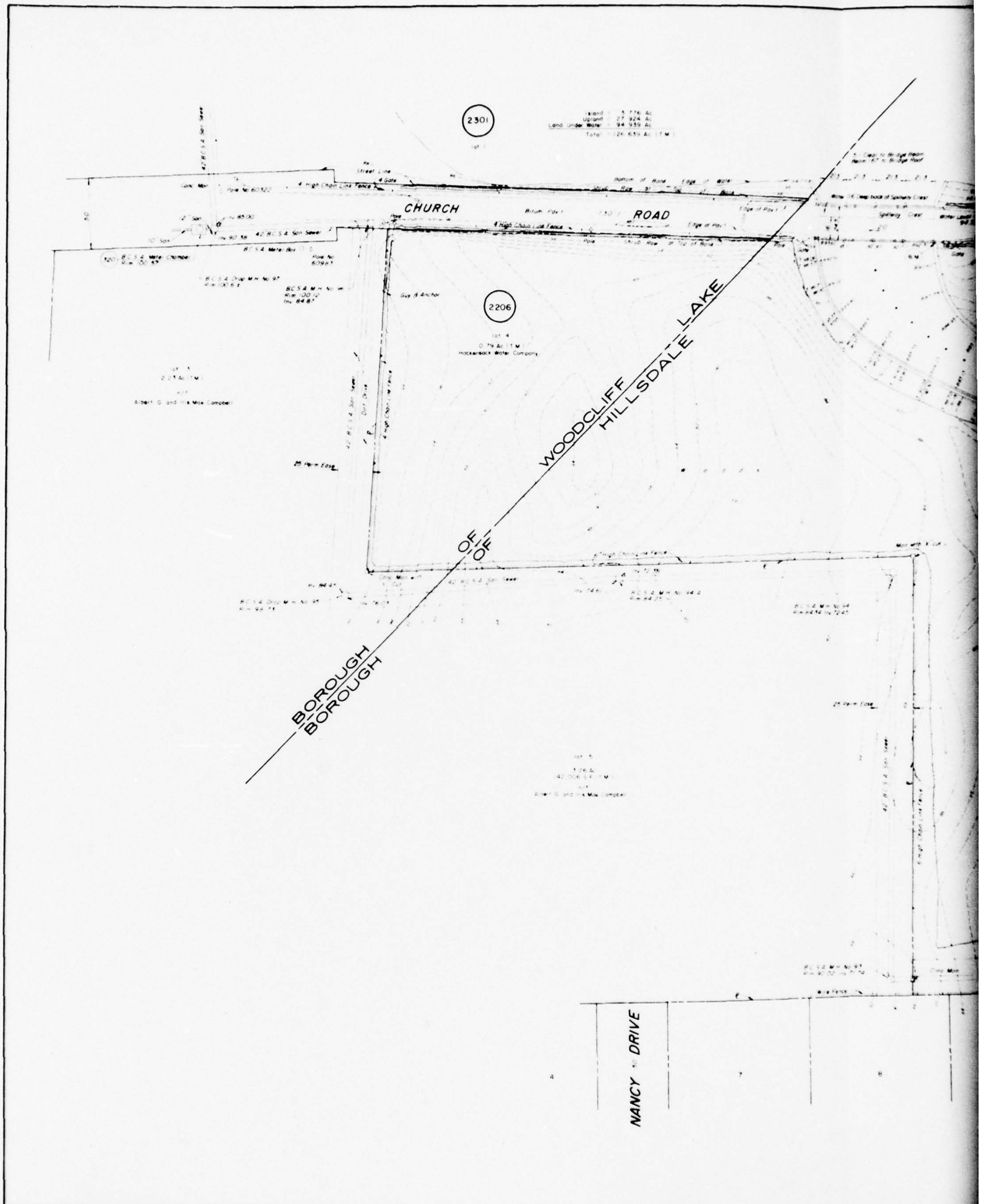
IMPROVEMENTS TO
WOODCLIFF LAKE SPILLWAY
HILLSDALE, N.J.

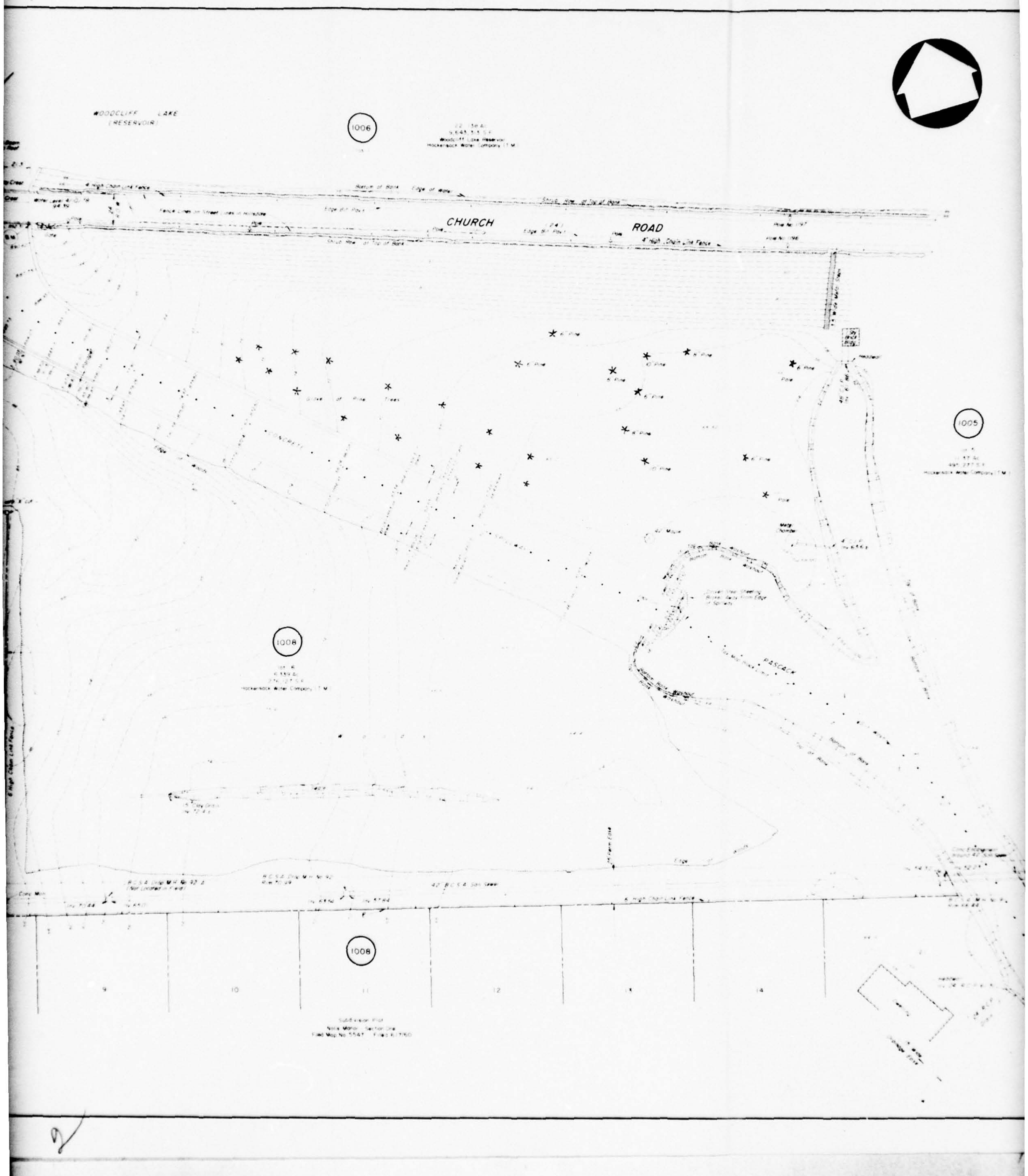
FLASHBOARD INSTALLATION & DETAILS

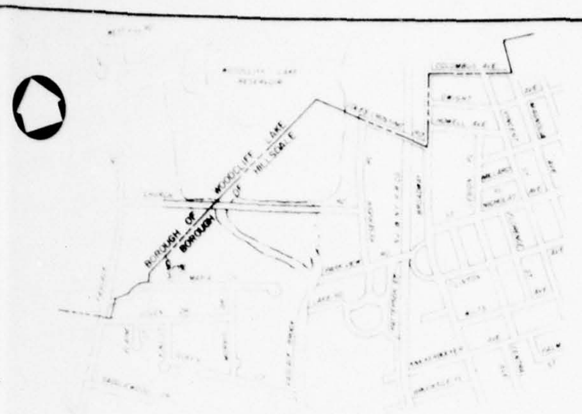
SCALE AS SHOWN — DATE AUG. 1976

| | | |
|---|---|---|
| BUDGET ITEM NO. | INVESTIGATION NO. | EXTENSION NO. |
| DRAWN BY FJM | CHECKED BY | APPROVED BY |

sion ① 10/7/76


2301
CHURCH
ROAD
2206
Hackensack Water Company
BOROUGH OF WOODCLIFF LAKE
BOROUGH OF HILLSDALE
Albert G. and Iris Mae Campbell
NANCY DRIVE


WOODCLIFF LAKE
(RESERVOIR)
1006
Woodcliff Lake Reservoir
Hackensack Water Company (T.M.)
Bottom of Bank
Edge of Water
CHURCH
ROAD
1005
Hackensack Water Company (T.M.)
CONCRETE
1008
Hackensack Water Company (T.M.)
PASCACK
6' High Chain Link Fence
1008
9
10
11
12
14
Subdivision Plat
Nola Manor  Section One
Filed Map No 5547  Filed 6/7/60




**KEY MAP**

SCALE 1" = 800'

**NOTES**

1. BENCH MARK (BM) U.S.G.S. DATUM ELEV. 101.54 BRONZE DISK S.E. WING WALL OF CHURCH ROAD BRIDGE
2. ALL 42" B.C.S.A. SAN. SEWER IS REINFORCED CONCRETE PIPE CLASS III, IV OR V. RIM ELEVATIONS ARE AS SHOT IN THE FIELD. INVERTS AND OTHER DATA FROM "BERGEN COUNTY SEWER AUTHORITY PASCACK VALLEY WEST EXTENSION PLAN AND PROFILE, CONTRACT 70, RECORD DRAWING 3, AUG 1972, REVISED 9/25/75 BY CLINTON BOGERT ASSOCIATES, CONSULTING ENGINEERS"
3. LOT AND BLOCK INFORMATION FROM: BOROUGH OF HILLSDALE TAX MAP SHEET NO. 10 AND BOROUGH OF WOODCLIFF LAKE TAX MAP SHEET NOS. 22 AND 23
4. T.M. = TAX MAP
5. CHURCH ROAD AND MUNICIPAL BOUNDARY SET FROM TAX MAP INFORMATION AND IS APPROXIMATE

# WOODCLIFF LAKE

## DWG. NO. 8

TOPOGRAPHIC MAP
FOR
HACKENSACK WATER CO.

BOROUGHS OF WOODCLIFF LAKE AND HILLSDALE
BERGEN COUNTY, NEW JERSEY

DRAWN BY: D.G. CHECKED BY: D.S.
SCALE: 1" = 30' DATE: APRIL 20, 1978

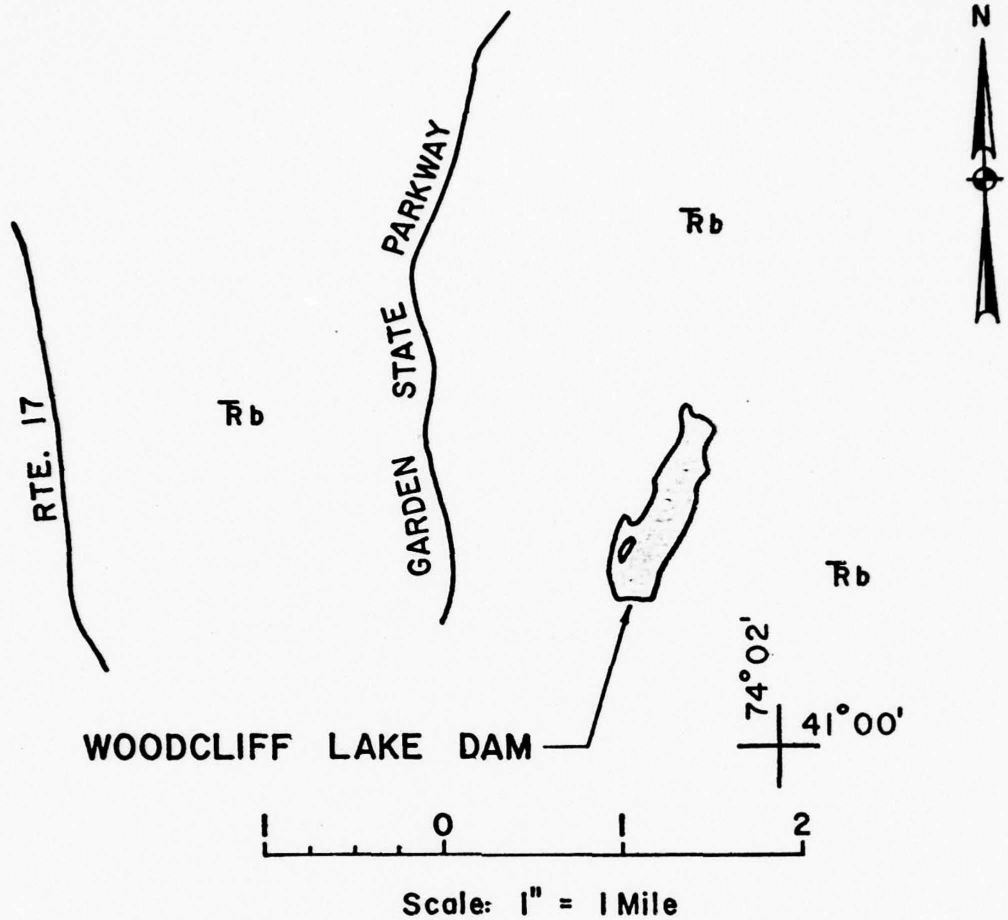
James P. Azzolina DATE 4/20/78
JAMES P. AZZOLINA, P.E. & L.S.
PROFESSIONAL ENGINEER & LAND SURVEYOR N.J. LIC. NO. 10431
PROFESSIONAL PLANNER N.J. LIC. NO. 1782

AZZOLINA ENGINEERING COMPANY
PROFESSIONAL ENGINEERS & LAND SURVEYORS
30 MADISON AVENUE PARAMUS, N.J.

A.E.C. JOB NO. 1757

3

4




## LEGEND

### TERTIARY

TRb Brunswick Formation
Soft Red Shale with Interbeds of Red Sandstone

NOTE: Glacial - Fluvial Sands and Gravels Mantling Bedrock in Pascack Brook Valley not Shown

# GEOLOGIC MAP
# WOODCLIFF LAKE

DWG. NO. 9

# APPENDIX A

CHECK LIST - VISUAL OBSERVATIONS

CHECK LIST - ENGINEERING, CONSTRUCTION
MAINTENANCE DATA

CHECK LIST
VISUAL INSPECTION
PHASE 1

Name Dam WOODCLIFF LAKE DAM    County Bergen    State New Jersey    Coordinators ____

Date(s) Inspection May 2, 1978 / May 6, 1978    Weather Partly Cloudy / Raining    Temperature 50°F / 55°F

Pool Elevation at Time of Inspection 93.27 M.S.L.    Tailwater at Time of Inspection Approx. 62.5 M.S.L. at low level outlet

Inspection Personnel:

Seymour Roth, May 2    William Flynn, May 2    Larry Woscyna, NJ-DEP, May 2

David Kerkes, May 2 and 5    Lynn Brown, May 6

Yin Au-Yeung, May 2

Recorder: Seymour M. Roth

Owner: Hackensack Water Company - Representatives: (on May 2, 1978)
- John Cannizo, Director, Engineering Design and Construction
- George M. Haskew, Jr., Senior Vice President, and Chief Engineer
- James Butler, Director of System Operation

## CONCRETE/MASONRY DAMS

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS AND RECOMMENDATIONS |
|---|---|---|
| SEE PAGE ON LEAKAGE | NA | |
| STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS | NA | |
| DRAINS | NA | |
| WATER PASSAGES | NA | |
| FOUNDATIONS | NA | |

CONCRETE/MASONRY DAMS

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
| --- | --- | --- |
| SURFACE CRACKS CONCRETE SURFACES | NA | |
| STRUCTURAL CRACKING | NA | |
| VERTICAL & HORIZONTAL ALIGNMENT | NA | |
| MONOLITH JOINTS | NA | |
| CONSTRUCTION JOINTS | NA | |

## EMBANKMENT

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|---|---|---|
| SURFACE CRACKS | None apparent; the top of the embankment is paved with a two - lane asphalt road. The cracks in the pavement are not considered to be related embankment cracking, movement or safety. | |
| UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE | None apparent or visible. | |
| SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES | None apparent. Upstream face of embankment is rip-rapped and in good condition. The downstream slope is covered in places with medium to heavy brush growth. The downstream embankment face does not appear to be firm or highly compacted. This could be because of the construction methods employed in 1903 utilized horse drawn compaction equipment or the foot deep loam layer. There are some active animal burrows visible on downstream face. | Clean D/S slope of brush and trees, and plant with grass or other suitable vegetative cover. Extend brush-free zone 35 ft. beyond toe of embankment line. |
| VERTICAL & HORIZONTAL ALIGNMENT OF THE CREST | No apparent deviations from line and grade are visible. The dam has been constructed on a straight line axis, whereas the original dam drawings available for inspection show that the right abutment part of the embankment curves upstream. | |
| RIPRAP FAILURES | No rip-rap failures were observed above the waterline. Rip-rap also extends for a good part of the reservoir rim between the embankment and the causeway crossing the reservoir at North of the causeway, there is no riprap shore protection. | |

EMBANKMENT

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS AND RECOMMENDATIONS |
|---|---|---|
| JUNCTION OR EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM | No unusual problems or conditions were noticed at the junction of the embankment with the abutments or the spillway. | |
| ANY NOTICEABLE SEEPAGE | Noticeable seepage exists in the left embankment section in the vicinity of the left abutment. Four separate seepage areas were observed, where the phreatic line intersects the ground at the toe or a short distance downstream of the toe. The natural ground, at these places, slopes away from the toe of the embankment. The seepage combines into a small rivulet 2-ft. wide, flowing at the rate of 5-10 gpm. The seepage water appears clear. One observation well 75 to left of the gate house shows the phreatic line at that location to be one foot below ground level. Large areas of skunk cabbage growth at the downstream toe of slope is a further indication of a high water table. | Suggest installation of a toe drain system that would lower the phreatic line 4 to 6 ft, to include inspection manholes that would allow monitoring of seepage rate and clarity of seepage water. |
| STAFF GAGE AND RECORDER | An automatic water level recorder on the left shore of the reservoir was not operating on day of inspection. The water levels are read out twice a day currently, and on an hourly basis when rainfall exceeds one inch per 24 hours. A rainfall recorder also is installed in the same vicinity. The rainfall recorder is surrounded by trees, perhaps affecting its accuracy. | Repair water level recorder to its intended function. |
| DRAINS | | |

## OUTLET WORKS

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS AND RECOMMENDATIONS |
|---|---|---|
| CRACKING & SPALLING OF CONCRETE SURFACES IN STILLING BASIN | The outlet conduit was not available for inspection due to its use in discharging water. The headwall of the outlet conduit is spalled but in serviceable condition. | |
| INTAKE STRUCTURE | There is no intake structure as such. The outlet pipe extends into the reservoir bottom through the embankment. There is no trash rack structure provided at the pipe inlet. | |
| OUTLET CHAMBER IN DAM | The outlet structure consists of a small gate house housing two 48-in. diameter valves in series, laid on their sides. The U/S emergency valve is manually operated, the D/S service valve is motor operated. The gate valve installation varies from the arrangement shown on dam drawings available. | Provide a correct plan showing outlet structure and valving configuration. |
| OUTLET FACILITIES | The 48-inch line discharges through a headwall directly into an outlet channel approximately 8-ft. wide, with rip-rapped invert and sides in acceptable condition. There is no stilling basin. The outlet channel joins the Pascack Brook at the end of the spillway chute channel. | |
| EMERGENCY GATE | One 36-inch diameter gate valve upstream of the motor operated service valve. | |

## UNGATED SPILLWAY

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS AND RECOMMENDATIONS |
|---|---|---|
| CONCRETE WEIR | Low concrete crest sill in acceptable condition. No major cracks, areas of deterioration or dislocations. | |
| APPROACH CHANNEL | A rip-rapped short approach channel upstream of the crest sill between wingwalls containing the embankment was in acceptable condition. | |
| DISCHARGE CHANNEL | Curved discharge channel leading into Pascack Brook. Walls and slabs have no cracks or dislocations. The floor has been repaved in 1976. The walls date from 1903. The right chute wall has been raised, 2'6", in 1976 to contain chute flow standing waves at supercritical flow. Repaving of chute floor has allegedly increased chute flow velocity, so that rain of Nov. 8, 1977 has caused severe downstream channel bank damage and tearing away steel pile cut-off at end of discharge chute. | Repair downstream sheet pile cut-off. Provide energy dissipation sill at end of channel chute slabs. |
| BRIDGE AND PIER | A four-span bridge setting on low, 5-ft. high pier carries Church Street over the spillway crest. The concrete in the three piers is in acceptable condition. The bridge beams have cantilever bracket supports which cut down the net spillway area. Abutment beam brackets appear to have been added after original construction. Some soffit repairs have been made on the upstream beam in the left bridge span opening consisting of 8 x 8 inch bottom flange encasement extending 1 or 2 in.below the original beam soffit line. | |
| DOWNSTREAM STREAM CHANNEL OF PASCACK BROOK | Rains of Nov. 8, 1977 have caused severe lateral bank erosion at end of discharge channel. The eroded material has been deposited in brook bed approx. 75 ft. downstream. According to Hackensack Water Co. officials, no significant depth of brook channel erosion exists, only lateral bank damage. | Regrade channel; remove eroded material downstream. Add heavy stone protection to bottom and bank slopes. |

GATED SPILLWAY

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS AND RECOMMENDATIONS |
|---|---|---|
| CONCRETE SILL | NA | |
| APPROACH CHANNEL | NA | |
| DISCHARGE CHANNEL | NA | |
| BRIDGE AND PIERS | NA | |
| GATES & OPERATION EQUIPMENT | NA | |

## INSTRUMENTATION

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS AND RECOMMENDATIONS |
|---|---|---|
| MONUMENTATION/ SURVEYS | None observed. | |
| OBSERVATION WELLS | One piezometer well approximately 75 ft. to left of gate house was observed. The water level was observed approximately one foot below ground level at this location. | |
| WEIRS | None. | |
| PIEZOMETERS | None. The owner is currently considering installation of piezometer. | Install piezometers in the embankment at seepage areas to trace phreatic line level. Add piezometers in non-leakage areas to calibrate normal non-leakage phreatic line. |
| OTHER | | |

## RESERVOIR

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS AND RECOMMENTATIONS |
|---|---|---|
| SLOPES | Generally gentle to flat. No signs of rim sloughing. Reservoir between causeway and dam axis has rip-rap protection consisting of cobble sized stone armoring at the water line extending 2 feet above it. | |
| SEDIMENTATION | Below the causeway, there seems to be no evidence of sedimentation. Above the causeway, some sedimentation exists due to new construction, not seriously affecting the reservoir capacity. | |
| | | |
| | | |

## DOWNSTREAM CHANNEL

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS AND RECOMMENDATIONS |
|---|---|---|
| CONDITION (OBSTRUCTIONS, DEBRIS, ETC.) | The channel banks downstream of the spillway chute have been seriously eroded in the rainstorm discharges of Nov. 8, 1977, removing a bank area of 100-foot long by 15-foot wide on each side of the spillway chute. The coarser materials have been redeposited in the channel some 50 to 75 ft. downstream of the end of the spillway chute. | Regrade downstream channel; restore banks and rip-rap bank slopes and stream bottom. |
| SLOPES | The slopes are well defined below the damaged areas described above. | |
| APPROXIMATE NUMBER OF HOMES AND POPULATION | Approximately 10 homes exist immediately downstream of the spillway chute. The downstream area is urbanized. | |
| | | |

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

| ITEM | REMARKS |
|---|---|
| PLAN OF DAM | Existing plans of original construction available.<br>Plans for reconstruction of spillway chute available.<br>New topographic survey 1978 for right abutment area available. |
| REGIONAL VICINITY MAP | Available. |
| CONSTRUCTION HISTORY | Available orally from Hackensack Water Co. officials.<br>Some records plans of post construction repairs and alterations available. |
| TYPICAL SECTIONS OF DAM | Available. |
| HYDROLOGIC/HYDRAULIC DATA | Rating curve for outlet and spillway is available.<br>Area capacity curve available.<br>Hydrographs for major storms available. |
| OUTLETS - PLAN | Available, but not accurate nor detailed, apparently not built according to plans. |
| - DETAILS | |
| - CONSTRAINTS | |
| - DISCHARGE RATINGS | Available |
| RAINFALL / RESERVOIR RECORDS | These are available but have not been inspected. |

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

| ITEM | REMARKS |
|---|---|
| DESIGN REPORTS | None available. |
| GEOLOGY REPORTS | None available. |
| DESIGN COMPUTATIONS | No original computation available. |
| HYDROLOGY & HYDRAULICS | Rating curves for discharge of spillway and outlet works. |
| DAM STABILITY | None. |
| SEEPAGE STUDIES | None. |
| MATERIALS INVESTIGATIONS | Very crude shallow depth investigation record available, but not considered useful. |
| BORING RECORDS | None. |
| LABORATORY | None. |
| FIELD | None. |
| POST-CONSTRUCTION SURVEYS OF DAM | 1978 topographic survey of right abutment has been made and is available. Purpose of survey is to locate a possible auxiliary spillway. |
| BORROW SOURCES | No records uncovered. According to Hackensack Water Co. officials, the dam was built of local materials. |
| SPILLWAY PLAN - SECTIONS | Available. |
| - DETAILS | Available. |

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

| ITEM | REMARKS |
| --- | --- |
| OPERATING EQUIPMENT PLANS AND DETAILS | None. |
| MONITORING SYSTEMS | A reservoir security patrol on 24-hour duty. Dam and reservoir are visited every hour. |
| MODIFICATIONS | A row of sheet piling was added in 1937 to the end of the spillway chute channel. Downstream rip-rap in Pascack Brook was also added then. The spillway chute channel was repaved in 1976 with 5 inches of concrete. The right chute wall was raised 2'-6" in the upper reaches. Flash boards were added to the spillway weir areas in 1976 but have been abandoned. |
| HIGH POOL RECORDS | Orally given by Hackensack Water Co. officials as one foot below dam crest in 1975. Water level in reservoir recorded twice a day, and on an hourly basis if rainfall exceeds one inch. |
| POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS | Currently a study is underway to add spillway capacity in the form of an auxiliary spillway on the right abutment area. |
| PRIOR ACCIDENTS OR FAILURE OF DAM - DESCRIPTION - REPORTS | The downstream brook channel was washed out in November 1977, eroding channel banks and causing damage to the steel sheet pile cut-off at the end of the spillway chute channel. |
| MAINTENANCE, OPERATION RECORDS | None. |

# APPENDIX B

## PHOTOGRAPHS

ALL PHOTOGRAPHS TAKEN DURING MAY 1978

Photo 1 - Looking at dam crest along Church Road toward left abutment from spillway bridge on right abutment

Photo 2 - Looking at dam embankment and low level outlet Gate House from downstream

Photo 3 - Low level outlet Gate House

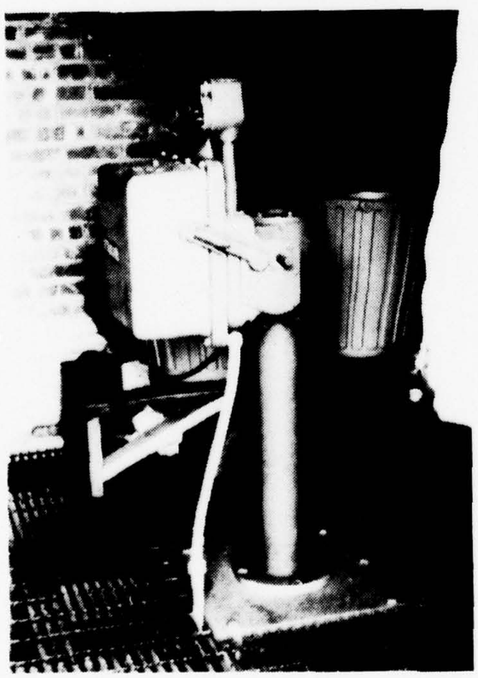


Photo 4 - Motor operated 36-inch service gate valve on 48-inch diameter low level line; hand operated 36-inch diameter emergency gate is upstream of service gate

Photo 5 - View of downstream face of embankment standing in left abutment area looking toward right abutment

Photo 6 - View of downstream face of embankment standing in left abutment area looking toward left abutment; note large areas of skunk cabbage growth at toe of embankment indicating high water table

Photo 7 - Detail of seepage area on left abutment-rivulet downstream of embankment toe

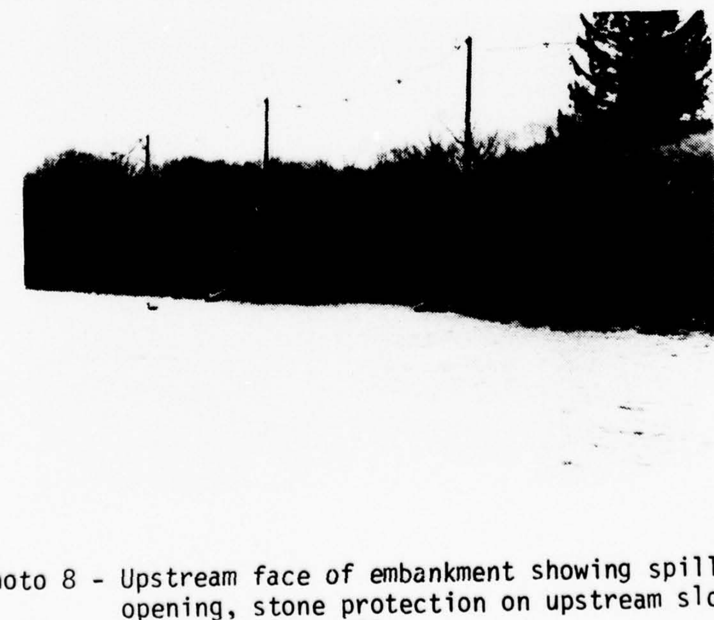


Photo 8 - Upstream face of embankment showing spillway opening, stone protection on upstream slope and approach wing walls

Photo 9 - Upstream face of embank-
embankment showing
stone protection at
the waterline; looking
toward left abutment

Photo 10 - Upstream face of spillway weir under spillway
bridge showing approach stone protection, and
abandoned and bent flashboard pins

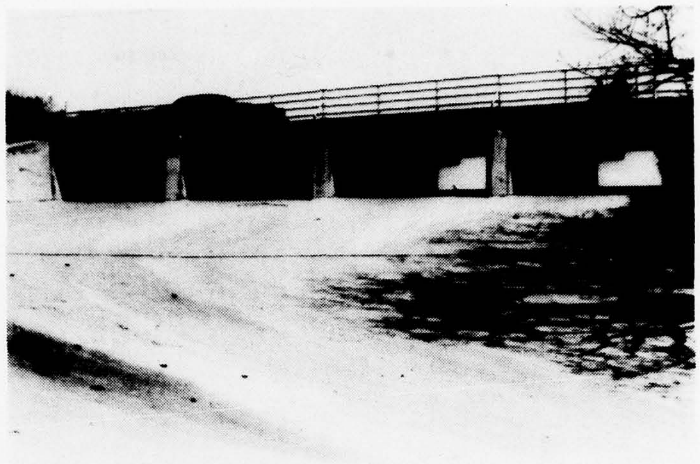


Photo 11 - View of spillway chute channel looking upstream at spillway bridge and Church Road; spillway chute turns through an angle of approximately 60 degrees at upper end

Photo 12 - View of spillway chute channel looking downstream; chute slab has been repaved in 1976

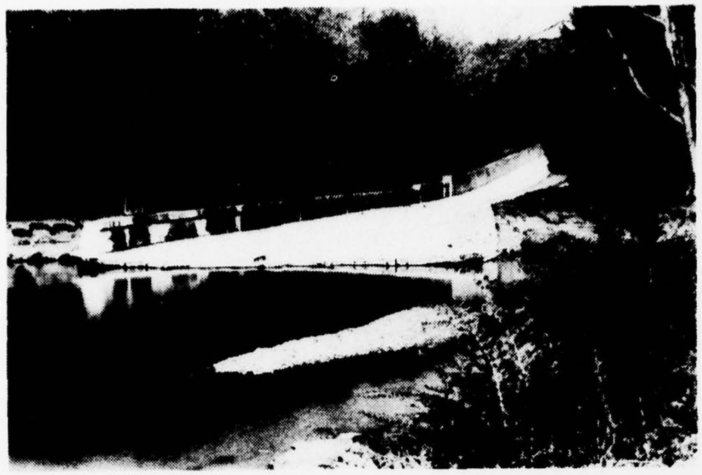


Photo 13 - View of spillway chute channel from downstream; Channel area downstream of chute wall has been severely eroded by spillway discharges during storm of November 8, 1977

Photo 14 - Detail of damage to steel sheet pile cut-off installed at end of spillway chute channel caused during storm of November 8, 1977. Sheet piling has been torn away from end of chute slab and bent downstream

Photo 15 - View of upstream face of causeway dividing Woodcliff Lake into two parts; connected by a single barrel culvert 25-foot wide by 18'-9" high

# APPENDIX C

## SUMMARY OF ENGINEERING DATA

# CHECK LIST
## HYDROLOGIC AND HYDRAULIC DATA
## ENGINEERING DATA

Name of Dam: WOODCLIFF LAKE DAM

Drainage Area Characteristics: 194 sq.mi. on the Pascack Brook, Hackensack River Bassin

Elevation Top Normal Pool (Storage Capacity): 94.33

Elevation Top Flood Control Pool (Storage Capacity): NA

Elevation Maximum Design Pool: 98.03

Elevation Top Dam: 100± (Length 1,500 ft.)

SPILLWAY CREST:

a. Elevation 94.33
b. Type Uncontrolled concrete overflow, brood crested weir under bridge
c. Width Broad crest
d. Length 79 ft. net opening
e. Location Spillover Near right abutment at Church Road bridge
f. No. and Type of Gates None

OUTLET WORK:

a. Type 1-36"Ø service gate valve, a 36"Ø emergency gate valve on a 48"Ø line
b. Location Center of embankment
c. Entrance Inverts 63.00±
d. Exit Inverts 61.86±
e. Emergency Draindown Facilities None

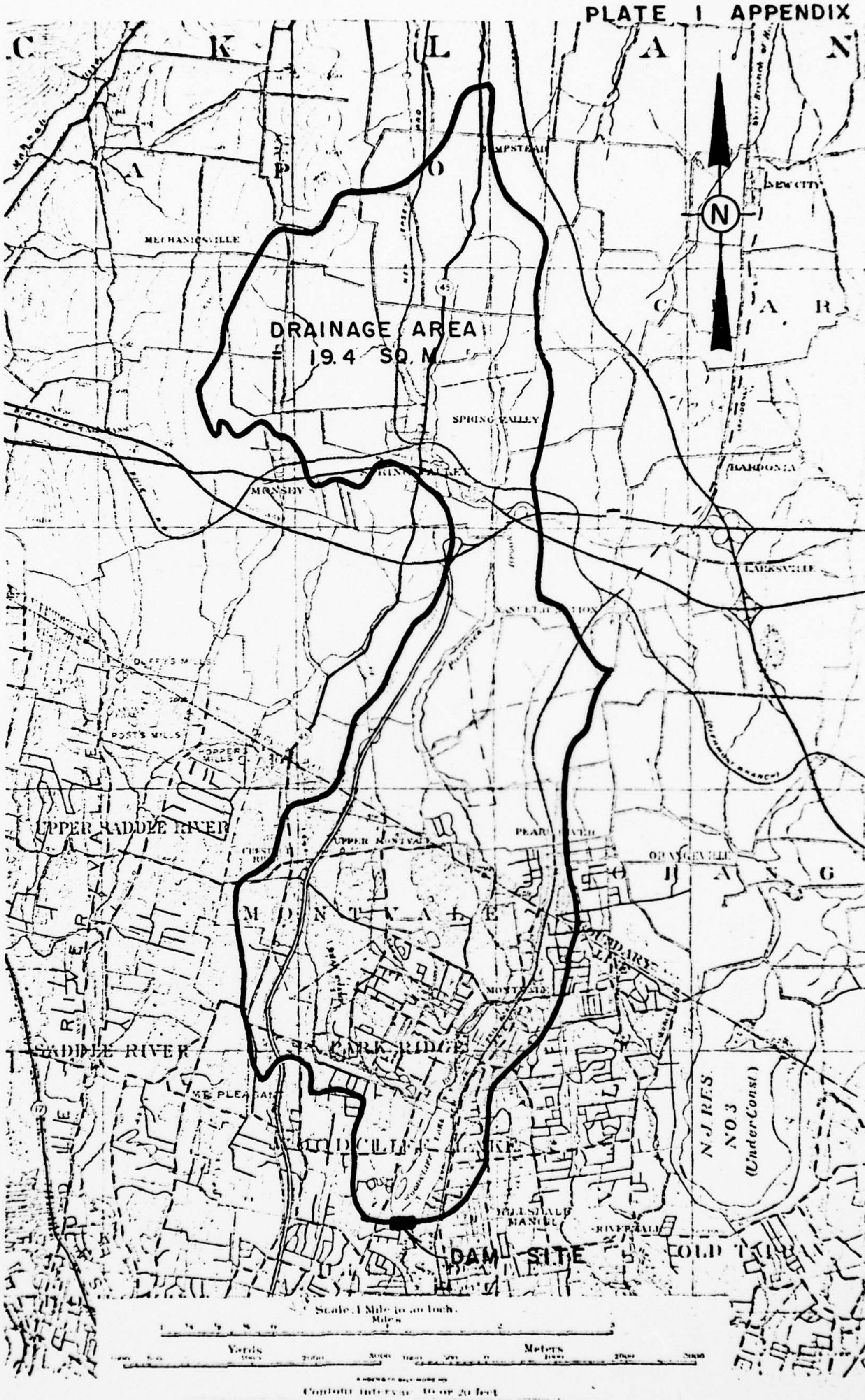
HYDROMETEOROLOGICAL GAGES: Two

a. Type One reservoir water level recorder and a rain gage
b. Location On left shore near dam
c. Records 1932 to current

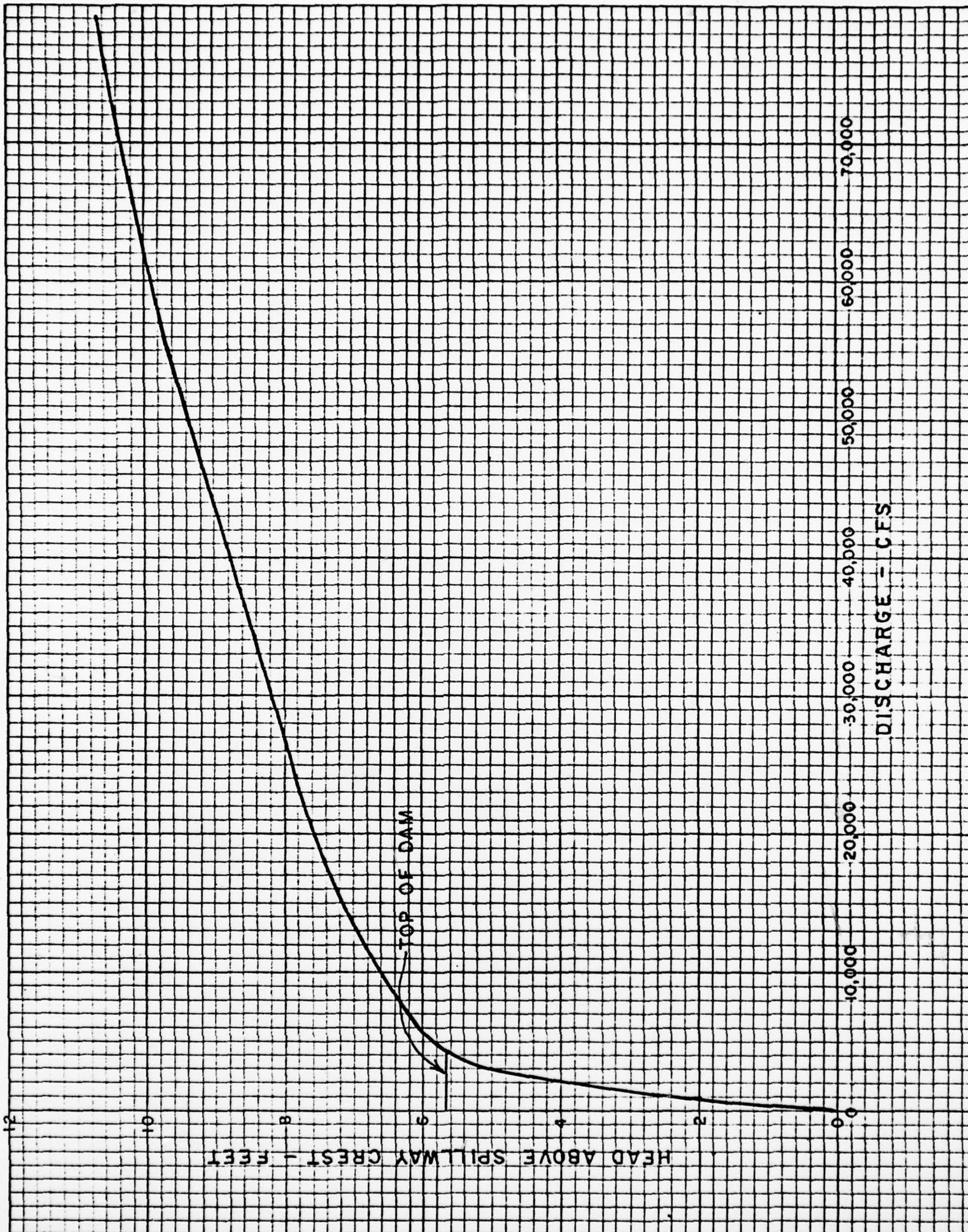
MAXIMUM NON-DAMAGING DISCHARGE: 1,650 cfs

# APPENDIX D

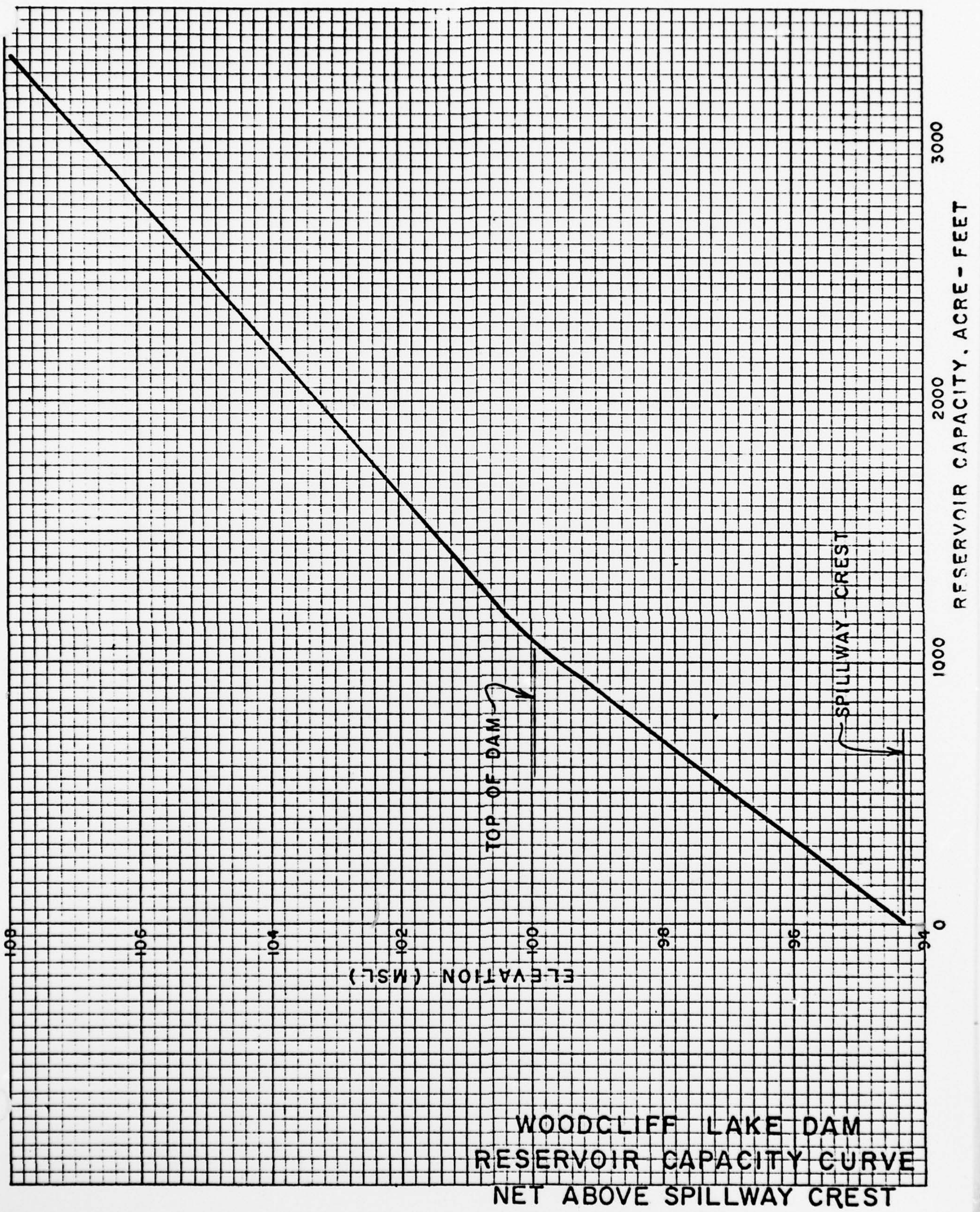
## HYDROLOGIC COMPUTATIONS




WOODCLIFF LAKE DAM - DRAINAGE BASIN

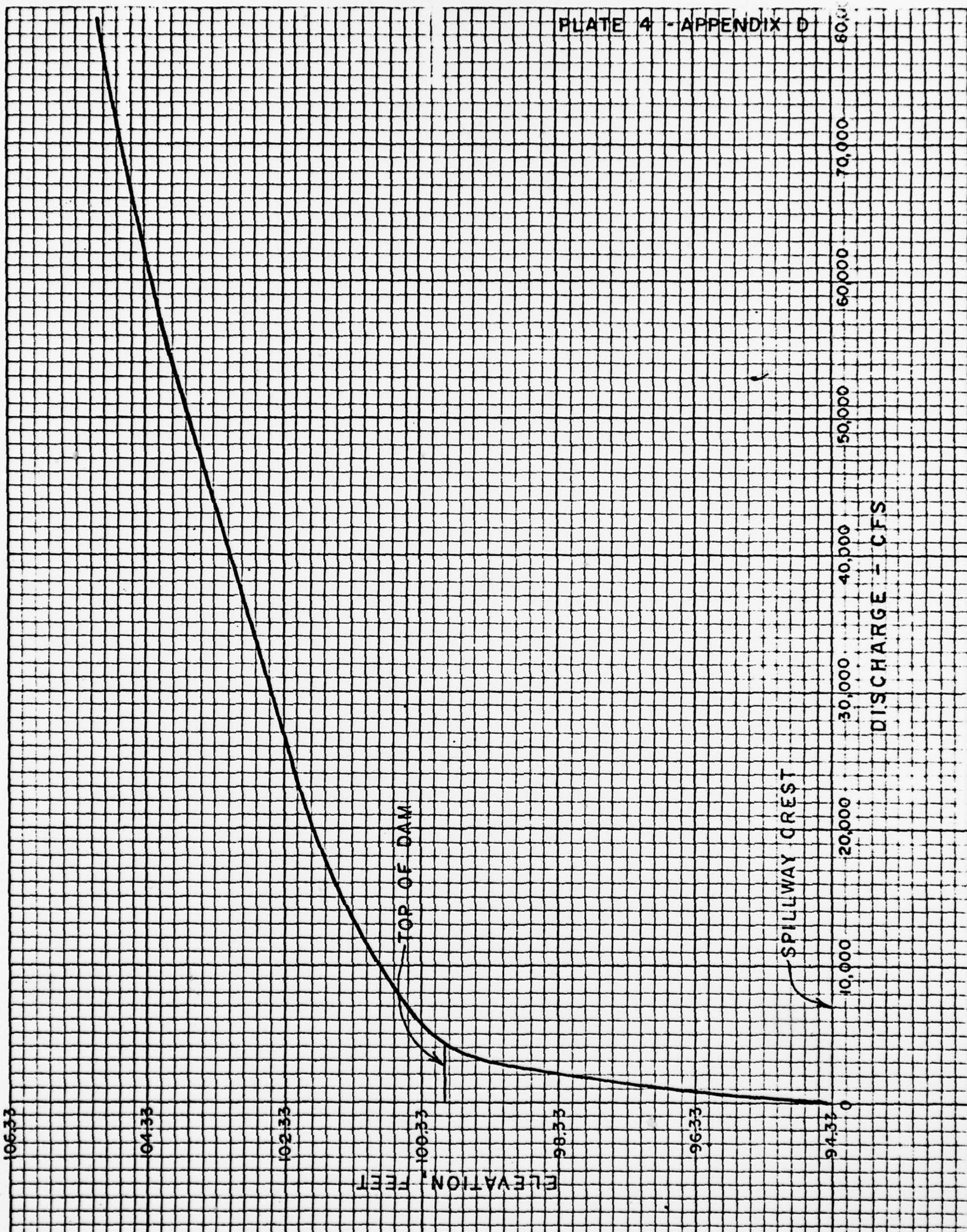



WOODCLIFF LAKE DAM
SPILLWAY RATING CURVE
ABOVE SPILLWAY CREST



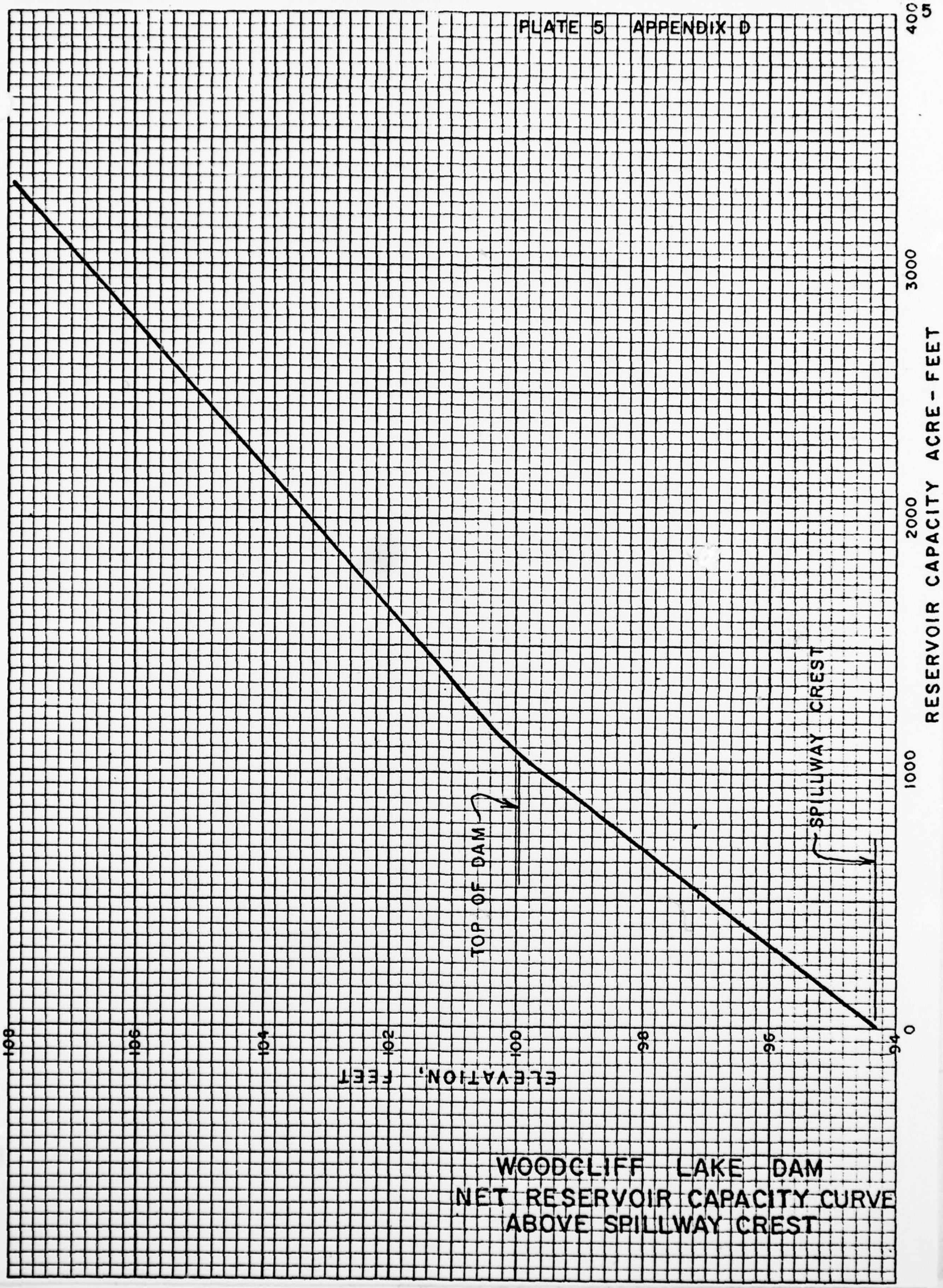

WOODCLIFF LAKE DAM
RESERVOIR CAPACITY CURVE
NET ABOVE SPILLWAY CREST

PLATE 4 - APPENDIX D




WOODCLIFF LAKE DAM
SPILLWAY & OVERTOP RATING CURVE

PLATE 5 APPENDIX D

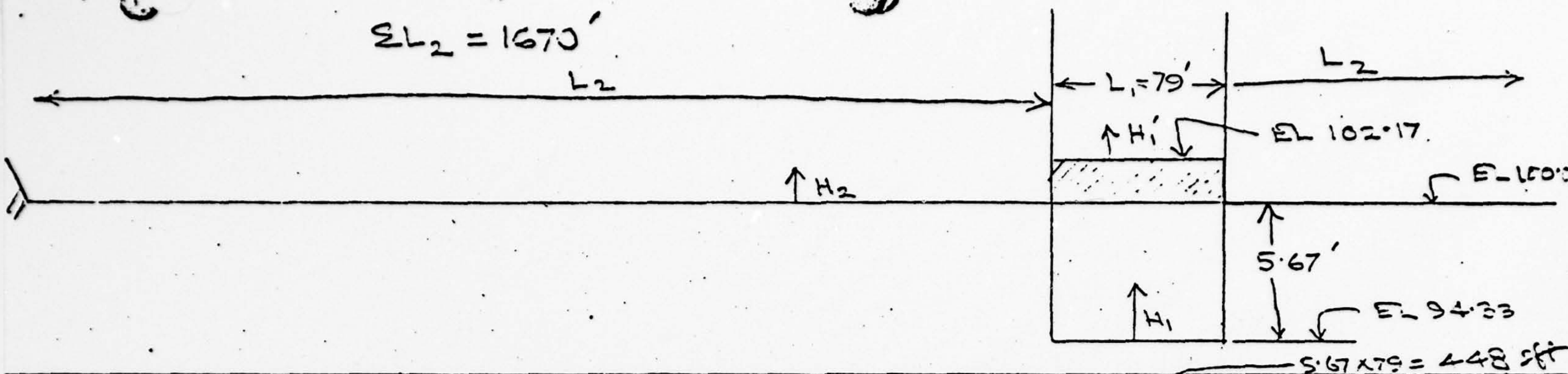



WOODCLIFF LAKE DAM
NET RESERVOIR CAPACITY CURVE
ABOVE SPILLWAY CREST

NEW JERSEY DAM SAFETY INSPECTION — SHEET NO. 1 OF

WOODCLIFF LAKE DAM — JOB NO. [illegible]

SPILLWAY [illegible] RATING CURVE — BY [illegible] DATE




| Elev. | $H_1$ | $H_1'$ | $H_2$ | $L_1$ | $L_1'$ | $L_2$ | $C_1$ | $C_1'$ | $C_2$ | $Q = C_1L_1H_1^{1.5}$ upto EL100<br>$Q = C_1A\sqrt{2gH_1} + C_1'L_1'H_1'^{1.5} + C_2L_2H_2^{1.5}$ above 100.00 |
|---|---|---|---|---|---|---|---|---|---|---|
| 94.33 | 0 | | | | | | | | | |
| 96.33 | 2 | | | 79 | | | 3.5 | | | 782+0+0 = 782 |
| 98.33 | 4 | | | 79 | | | 3.65 | | | 2307+0+0 = 2,307 |
| 100.00 | 5.67 | | 0 | 79 | | 0 | 3.80 | | 0 | 4053+0+0 = 4,053 |
| 101.00 | 6.67 | | 1 | 79 | | 1670 | *0.60 | | 3.3 | 5570+0+5511 = 11,081 |
| 102.17 | 7.84 | 0 | 2.17 | 79 | 0 | 1670 | *0.60 | 0 | 3.4 | 6039+0+18150 = 24,189 |
| 104 | 9.67 | 1.83 | 4 | 79 | 79 | 1670 | *0.60 | 3.3 | 3.6 | 6707+645+48096 = 55,448 |
| 105 | 10.67 | 2.83 | 5 | 79 | 79 | 1670 | *0.60 | 3.4 | 3.8 | 7045+1279+70950 = 79,274 |

NEW JERSEY DAM SAFETY INSPECTION — SHEET NO. 1 OF 1

WOODCLIFF LAKE DAM — JOB NO. 1209-001

RESERVOIR AREA CAPACITY DATA — BY MAS — DATE July 77

## WOODCLIFF LAKE DAM

## RESERVOIR AREA CAPACITY DATA

### SUMMARY

| Elevation (Feet) | Reservoir Surface Area (Acres) | Incremental Volume of Reservoir (AC-FT) | Net Vol. of Reservoir Above El. 94.33 | Remarks |
|---|---|---|---|---|
| 94.33 | 169 | 0 | 0 | Area is obtained from existing Reservoir Water Surface Elevation vs Area Curves |
| 95.00 | 172 | 114 | 114 | " |
| 95.50 | 176 | 87 | 201 | " |
| 100 | 217 | 884 | 1085 | Area is obtained from USGS topo maps |
| 110 | 344.8 | 2809 | 3894 | " |

ECI-4 **ENGINEERING CONSULTANTS, INC.** 

WOOD CLIFF DAM — SHEET NO. 1 OF

NEW COMPUTATION OF POINTS — JOB NO. 1209-001-1

ON Y2 & Y3 CARDS FOR HEC-1 — BY KLB DATE 7-5-78

TABULATION OF ELEVATION, HEAD ABOVE SPILLWAY CREST ETC.

| # | ELEVATION | HEIGHT ABOVE CREST | Y2 STORAGE (AC-FT) | Y3 DISCHARGE (CFS) |
|---|---|---|---|---|
| 1 | 94.33 | 0' | 0. | 0. |
| 2 | 97.0 | 2.67 | 509. | 1200. |
| 3 | 99.0 | 4.67 | 890. | 3000. |
| 4 | 99.5 | 5.17 | 985. | 3600. |
| 5 | 100.0 | 5.67 | 1080. | 4900. |
| 6 | 100.5 | 6.17 | 1221 | 7000. |
| 7 | 101.0 | 6.67 | 1361. | 10000. |
| 8 | 102.0 | 7.67 | 1643. | 18200. |
| 9 | 103.5 | 9.17 | 2064. | 36000. |
| 10 | 105.0 | 10.67 | 2486. | 61800. |

DATA TAKEN FROM [illegible] CURVES

NOTE: CAPACITY CURVE IS TWO STRAIGHT LINES DEFINED BY THE FOLLOWING 3 POINTS

| | ELEV. (FT) | CAP. (AC-FT) |
|---|---|---|
| SPILLWAY CREST | 94.33 | 0 |
| TOP OF DAM | 100.00 | 1080 |
| LIMIT OF DATA | 108 | 3330 |

PROBABLE MAXIMUM FLOOD CALCULATION (PMF)

DRAINAGE AREA = 19.4 square miles.

From Hydrometeorological Report #33

"Seasonal Variation of the Probable Maximum Precipitation East of the 105 th Meridian for Areas from 10 to 1,000 square miles and Duration of 6, 12, 24 and 48 Hours" 1956.

For Drainage Area 10 square miles

The 6 Hour duration PMP is 25" inches for Zone "6" at Woodcliff Lake watershed.

Since the drainage area is larger than 10 square miles, an area reduction factor of 0.94 is applied.

The reduced 6 Hour PMP is 0.94 × 25" = 23.75 inches.

PMP values for rainfall durations of 6, 12, 24, 48 hours are:

| Duration (Hrs) | PMP (inches) |
|---|---|
| 6 Hr. | 1 × 23.75" = 23.75" |
| 12 Hr. | 1.09 × 23.75 = 25.89 |
| 24 Hr. | 1.17 × 23.75 = 27.79 |
| 48 Hr. | 1.27 × 23.75 = 30.16 |

PMP values shown above are reduced by 18.8% to account for misalignment of basin and rainfall isohyetals.

The PMP for deriving PMF are therefore as following:

| Duration (Hrs) | PMP (inches) |
|---|---|
| 6 | 19.29 |
| 12 | 21.02 |
| 24 | 22.57 |
| 48 | 24.49 |

WOODCLIFF LAKE DAM.

PMP-PMF DERIVATION

______ :

1) SOIL GROUP "C", & AMC-II

2) CN = 80

SOLUTION

1) SOIL GROUP "C" $\Rightarrow$ 0.12"/hr minimum loss rate

2) CN = 80 $\Rightarrow$ S = 2.50 in

Eq $$Q = \frac{(P-0.2S)^2}{P+0.8S}$$

Thus

$$Q = \frac{(P-0.50)^2}{P+2.0}$$

See page 2 for the remainder of the solution.

AD-A058 153 HARRIS ECI ASSOCIATES WOODBRIDGE NJ F/G 13/2
NATIONAL DAM SAFETY PROGRAM. WOODCLIFF LAKE DAM (NJ00247). HACK--ETC(U)
JUN 78 R GERSHOWITZ DACW61-78-C-0100

UNCLASSIFIED NL

2 OF 2
AD
A058153

END
DATE
FILMED
10-78
DDC

New Jersey Dam Safety Inspection — SHEET NO. 2 OF
PMF Derivation - Woodcliff Lake Dam — JOB NO. 1209
Probable Maximum Flood - UHG — BY Y.N DATE May 1978

DERIVATION OF UNIT HYDROGRAPH

This dam is located on the Pascack River Portion of the Hackensack River Basin. D.A. = 19.4 sq.mi.

Synder method is adopted for the derivation of UHG with

$C_t = 4.3$ and

$640\ C_p = 530$ , or $C_p = 0.828$

From topographic map we have

$L = 10.2$ mi.

$L_c = 4.3$ mi

$S = 0.0112$



Therefore

$t_p = C_t (L L_c)^{0.3}$

$= 4.3 (10.2 \times 4.3)^{0.3}$

$= \underline{13.37}$

$t_r = t_p / 5.5 = 13.37 / 5.5 = \underline{2.43\ hr}$

$q_p = 640\ C_p / t_p = 530 / 13.37 = \underline{39.6\ cfs}$

For $t_R = 2$ hr.

$t_{pR} = t_p + .25 (t_R - t_r) = \underline{13.26}$ hrs.

$q_{pR} = 640\ C_p / t_{pR} = 530 / t_{pR} = 39.97$

$Q_p = 39.97 \times 19.4 = 775.4$ cfs

# HEC 1 - COMPUTATIONS

```
********************************
HEC-1 VERSION DATED JAN 1973

********************************
                         DAM SAFETY INSPECTION - NEW JERSEY
                              WOODCLIFF LAKE DAM
                                   PMF FLOOD ROUTING
                          0.31
                                 JOB SPECIFICATION
               NQ    NHR   NMIN   IDAY    IHR   IMIN  METRC   IPLT   IPRT  NSTAN
               90      1      0      0      0      0      0      0      0      0
                                  JOPER    NWT
                                      3      0

     **********     **********     **********     **********     **********

                              SUB-AREA RUNOFF COMPUTATION

                         INPUT SNYDER COEFFICIENTS THEN MULTIPLY BY 0.5

                  ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME
                      5       0       0       0       0       0       1

                                    HYDROGRAPH DATA
          IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
              0       1   19.40    0.00   19.40    0.00   0.310       0       0       0

                                      PRECIP DATA
                                 NP   STORM     DAJ     DAK
                                 24    0.00    0.00    0.00
                                    PRECIP PATTERN
      0.00      0.00      0.00      0.02      0.04      0.06      0.07      0.06      0.06      0.06
      0.06      0.07      1.46      2.03      2.71      7.11      2.58      2.00      0.06      0.06
      0.07      0.06      0.06      0.06

                                       LOSS DATA
          STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
           0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00

                                  UNIT HYDROGRAPH DATA
                             TP= 13.37      CP=0.82      NTA=   0

                                     RECESSION DATA
                    STRTQ=     0.00     QRCSN=     0.00     RTIOR= 1.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=17.56 AND R= 5.88 INTERVALS

         UNIT HYDROGRAPH 42 END-OF-PERIOD ORDINATES, LAG=  13.35 HOURS, CP= 0.82  VOL= 0.99
       18.       69.      137.      213.      292.      372.      452.      530.      607.      674.
      723.      755.      769.      769.      755.      726.      682.      612.      524.      442.
      373.      314.      265.      223.      188.      159.      134.      113.       95.       80.
       68.       57.       48.       40.       34.       29.       24.       20.       17.       14.
       12.       10.

                                   END-OF-PERIOD FLOW
                              TIME   RAIN   EXCS   COMP Q
                                 1   0.00   0.00       0.
```

| | | | |
|---|---|---|---|
| 2 | 0.00 | 0.00 | 0. |
| 3 | 0.00 | 0.00 | 0. |
| 4 | 0.02 | 0.02 | 0. |
| 5 | 0.04 | 0.04 | 2. |
| 6 | 0.06 | 0.06 | 6. |
| 7 | 0.07 | 0.07 | 15. |
| 8 | 0.06 | 0.06 | 28. |
| 9 | 0.06 | 0.06 | 46. |
| 10 | 0.06 | 0.06 | 69. |
| 11 | 0.06 | 0.06 | 97. |
| 12 | 0.07 | 0.07 | 130. |
| 13 | 1.46 | 1.46 | 194. |
| 14 | 2.03 | 2.03 | 343. |
| 15 | 2.71 | 2.71 | 632. |
| 16 | 7.11 | 7.11 | 1185. |
| 17 | 2.58 | 2.58 | 2075. |
| 18 | 2.00 | 2.00 | 3235. |
| 19 | 0.06 | 0.06 | 4565. |
| 20 | 0.06 | 0.06 | 5970. |
| 21 | 0.07 | 0.07 | 7397. |
| 22 | 0.06 | 0.06 | 8805. |
| 23 | 0.06 | 0.06 | 10151. |
| 24 | 0.06 | 0.06 | 11387. |
| 25 | 0.00 | 0.00 | 12440. |
| 26 | 0.00 | 0.00 | 13233. |
| 27 | 0.00 | 0.00 | 13734. |
| 28 | 0.00 | 0.00 | 13945. |
| 29 | 0.00 | 0.00 | 13879. |
| 30 | 0.00 | 0.00 | 13532. |
| 31 | 0.00 | 0.00 | 12896. |
| 32 | 0.00 | 0.00 | 11983. |
| 33 | 0.00 | 0.00 | 10798. |
| 34 | 0.00 | 0.00 | 9444. |
| 35 | 0.00 | 0.00 | 8100. |
| 36 | 0.00 | 0.00 | 6883. |
| 37 | 0.00 | 0.00 | 5832. |
| 38 | 0.00 | 0.00 | 4938. |
| 39 | 0.00 | 0.00 | 4177. |
| 40 | 0.00 | 0.00 | 3530. |
| 41 | 0.00 | 0.00 | 2980. |
| 42 | 0.00 | 0.00 | 2514. |
| 43 | 0.00 | 0.00 | 2121. |
| 44 | 0.00 | 0.00 | 1789. |
| 45 | 0.00 | 0.00 | 1509. |
| 46 | 0.00 | 0.00 | 1272. |
| 47 | 0.00 | 0.00 | 1073. |
| 48 | 0.00 | 0.00 | 904. |
| 49 | 0.00 | 0.00 | 762. |
| 50 | 0.00 | 0.00 | 642. |
| 51 | 0.00 | 0.00 | 541. |
| 52 | 0.00 | 0.00 | 456. |
| 53 | 0.00 | 0.00 | 384. |
| 54 | 0.00 | 0.00 | 323. |
| 55 | 0.00 | 0.00 | 260. |
| 56 | 0.00 | 0.00 | 201. |
| 57 | 0.00 | 0.00 | 146. |
| 58 | 0.00 | 0.00 | 60. |
| 59 | 0.00 | 0.00 | 28. |
| 60 | 0.00 | 0.00 | 6. |
| 61 | 0.00 | 0.00 | 4. |
| 62 | 0.00 | 0.00 | 3. |

| | | | |
|---|---|---|---|
| 63 | 0.00 | 0.00 | 2. |
| 64 | 0.00 | 0.00 | 1. |
| 65 | 0.00 | 0.00 | 0. |
| 66 | 0.00 | 0.00 | 0. |
| 67 | 0.00 | 0.00 | 0. |
| 68 | 0.00 | 0.00 | 0. |
| 69 | 0.00 | 0.00 | 0. |
| 70 | 0.00 | 0.00 | 0. |
| 71 | 0.00 | 0.00 | 0. |
| 72 | 0.00 | 0.00 | 0. |
| 73 | 0.00 | 0.00 | 0. |
| 74 | 0.00 | 0.00 | 0. |
| 75 | 0.00 | 0.00 | 0. |
| 76 | 0.00 | 0.00 | 0. |
| 77 | 0.00 | 0.00 | 0. |
| 78 | 0.00 | 0.00 | 0. |
| 79 | 0.00 | 0.00 | 0. |
| 80 | 0.00 | 0.00 | 0. |
| 81 | 0.00 | 0.00 | 0. |
| 82 | 0.00 | 0.00 | 0. |
| 83 | 0.00 | 0.00 | 0. |
| 84 | 0.00 | 0.00 | 0. |
| 85 | 0.00 | 0.00 | 0. |
| 86 | 0.00 | 0.00 | 0. |
| 87 | 0.00 | 0.00 | 0. |
| 88 | 0.00 | 0.00 | 0. |
| 89 | 0.00 | 0.00 | 0. |
| 90 | 0.00 | 0.00 | 0. |
| SUM | 18.76 | 18.76 | 233683. |

| | PEAK | 6-HOUR | 24-HOUR | 72-HOUR | TOTAL VOLUME |
|---|---|---|---|---|---|
| CFS | 13945. | 13536. | 8910. | 3245. | 233685. |
| INCHES | | 6.49 | 17.08 | 18.67 | 18.67 |
| AC-FT | | 6715. | 17682. | 19322. | 19322. |

RUNOFF MULTIPLIED BY 0.31

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0. | 0. | 0. | 0. | 0. | 2. | 4. | 8. | 14. | 21. |
| 30. | 40. | 60. | 106. | 196. | 367. | 643. | 1002. | 1415. | 1850. |
| 2293. | 2729. | 3146. | 3530. | 3856. | 4102. | 4257. | 4323. | 4302. | 4195. |
| 3997. | 3714. | 3347. | 2927. | 2511. | 2133. | 1808. | 1530. | 1295. | 1094. |
| 924. | 779. | 657. | 554. | 467. | 394. | 332. | 280. | 236. | 199. |
| 167. | 141. | 119. | 100. | 80. | 62. | 45. | 18. | 8. | 1. |
| 1. | 1. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |

| | PEAK | 6-HOUR | 24-HOUR | 72-HOUR | TOTAL VOLUME |
|---|---|---|---|---|---|
| CFS | 4323. | 4196. | 2762. | 1006. | 72442. |
| INCHES | | 2.01 | 5.29 | 5.78 | 5.78 |
| AC-FT | | 2081. | 5481. | 5990. | 5990. |

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE HALF OF PMF HYDROGRAPH THRU WOODCLIFF LAKE DAM

| ISTAQ | ICOMP | IECON | ITAPE | JPLT | JPRT | INAME |
|---|---|---|---|---|---|---|
| 5 | 1 | 0 | 0 | 0 | 0 | 1 |

ROUTING DATA

| QLOSS | CLOSS | AVG | IRES | ISAME |
|---|---|---|---|---|
| 0.0 | 0.000 | 0.00 | 1 | 0 |

| NSTPS | NSTDL | LAG | AMSKK | X | TSK | STORA |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0.000 | 0.000 | 0.000 | -1. |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| STORAGE= | 0. | 509. | 890. | 985. | 1080. | 1221. | 1361. | 1643. | 2064. | 2486. |
| OUTFLOW= | 0. | 1200. | 3000. | 3600. | 4900. | 7000. | 10000. | 18200. | 36000. | 61800. |

| TIME | EOP STOR | AVG IN | EOP OUT |
|---|---|---|---|
| 1 | 0. | 0. | 0. |
| 2 | 0. | 0. | 0. |
| 3 | 0. | 0. | 0. |
| 4 | 0. | 0. | 0. |
| 5 | 0. | 0. | 0. |
| 6 | 0. | 1. | 0. |
| 7 | 0. | 3. | 0. |
| 8 | 0. | 6. | 1. |
| 9 | 1. | 11. | 3. |
| 10 | 2. | 18. | 6. |
| 11 | 4. | 26. | 9. |
| 12 | 6. | 35. | 14. |
| 13 | 8. | 50. | 20. |
| 14 | 13. | 83. | 31. |
| 15 | 22. | 151. | 53. |
| 16 | 39. | 281. | 93. |
| 17 | 70. | 505. | 166. |
| 18 | 120. | 823. | 283. |
| 19 | 189. | 1209. | 447. |
| 20 | 279. | 1633. | 658. |
| 21 | 385. | 2072. | 909. |
| 22 | 506. | 2511. | 1193. |
| 23 | 627. | 2938. | 1758. |
| 24 | 736. | 3338. | 2274. |
| 25 | 834. | 3693. | 2737. |
| 26 | 918. | 3979. | 3181. |
| 27 | 984. | 4180. | 3594. |
| 28 | 1021. | 4290. | 4093. |
| 29 | 1032. | 4312. | 4252. |
| 30 | 1032. | 4248. | 4249. |
| 31 | 1024. | 4096. | 4139. |
| 32 | 1009. | 3856. | 3934. |
| 33 | 988. | 3531. | 3643. |
| 34 | 955. | 3137. | 3415. |
| 35 | 910. | 2719. | 3127. |
| 36 | 855. | 2322. | 2837. |
| 37 | 795. | 1970. | 2554. |
| 38 | 734. | 1669. | 2265. |
| 39 | 675. | 1413. | 1986. |
| 40 | 620. | 1194. | 1728. |
| 41 | 571. | 1009. | 1493. |
| 42 | 526. | 851. | 1283. |
| 43 | 485. | 718. | 1145. |
| 44 | 445. | 606. | 1049. |
| 45 | 404. | 511. | 953. |
| 46 | 365. | 431. | 861. |
| 47 | 327. | 363. | 772. |
| 48 | 292. | 306. | [illegible] |

| | | | |
|---|---|---|---|
| 49 | 260. | 258. | 613. |
| 50 | 230. | 217. | 543. |
| 51 | 203. | 183. | 479. |
| 52 | 178. | 154. | 421. |
| 53 | 156. | 130. | 369. |
| 54 | 137. | 109. | 323. |
| 55 | 119. | 90. | 282. |
| 56 | 103. | 71. | 244. |
| 57 | 89. | 53. | 210. |
| 58 | 76. | 32. | 179. |
| 59 | 63. | 13. | 149. |
| 60 | 52. | 5. | 124. |
| 61 | 43. | 1. | 102. |
| 62 | 35. | 1. | 84. |
| 63 | 29. | 0. | 69. |
| 64 | 24. | 0. | 57. |
| 65 | 20. | 0. | 47. |
| 66 | 16. | 0. | 38. |
| 67 | 13. | 0. | 31. |
| 68 | 11. | 0. | 26. |
| 69 | 9. | 0. | 21. |
| 70 | 7. | 0. | 17. |
| 71 | 6. | 0. | 14. |
| 72 | 5. | 0. | 12. |
| 73 | 4. | 0. | 9. |
| 74 | 3. | 0. | 8. |
| 75 | 2. | 0. | 6. |
| 76 | 2. | 0. | 5. |
| 77 | 1. | 0. | 4. |
| 78 | 1. | 0. | 3. |
| 79 | 1. | 0. | 3. |
| 80 | 1. | 0. | 2. |
| 81 | 0. | 0. | 2. |
| 82 | 0. | 0. | 1. |
| 83 | 0. | 0. | 1. |
| 84 | 0. | 0. | 1. |
| 85 | 0. | 0. | 0. |
| 86 | 0. | 0. | 0. |
| 87 | 0. | 0. | 0. |
| 88 | 0. | 0. | 0. |
| 89 | 0. | 0. | 0. |
| 90 | 0. | 0. | 0. |
| SUM | | | 72440. |



| | PEAK | 6-HOUR | 24-HOUR | 72-HOUR | TOTAL VOLUME |
|---|---|---|---|---|---|
| CFS | 4252. | 4052. | 2620. | 1005. | 72440. |
| INCHES | | 1.94 | 5.02 | 5.78 | 5.78 |
| AC-FT | | 2010. | 5200. | 5988. | 5989. |

********** ********** ********** ********** **********



RUNOFF SUMMARY, AVERAGE FLOW

| | | PEAK | 6-HOUR | 24-HOUR | 72-HOUR | AREA |
|---|---|---|---|---|---|---|
| HYDROGRAPH AT | 5 | 4323. | 4196. | 2762. | 1006. | 19.40 |
| ROUTED TO | 5 | 4252. | 4052. | 2620. | 1005. | 19.40 |

```
******************************
HEC-1 [illegible]SION DATED JAN 1973

******************************

                         DAM SAFETY INSPECTION - NEW JERSEY
                               WOODCLIFF LAKE DAM
                           ONE HALF PMF FLOOD ROUTING

                              JOB SPECIFICATION
          NQ    NHR   NMIN   IDAY    IHR   IMIN  METRC   IPLT   IPRT  NSTAN
          90      1      0      0      0      0      0      0      0      0
                                  JOPER    NWT
                                      3      0


  **********         **********         **********         **********         **********

                           SUB-AREA RUNOFF COMPUTATION

                        INPUT SNYDER COEFFICIENTS THEN MULTIPLY BY 0.5

          ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME
              5       0       0       0       0       0       1

                               HYDROGRAPH DATA
   IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
       0       1   19.40    0.00   19.40    0.00   0.500       0       0       0

                                  PRECIP DATA
                             NP   STORM     DAJ     DAK
                             24    0.00    0.00    0.00
                                PRECIP PATTERN
    0.00      0.00      0.00      0.02      0.04      0.06      0.07      0.06      0.06      0.06
    0.06      0.07      1.46      2.03      2.71      7.11      2.58      2.00      0.06      0.06
    0.07      0.06      0.06      0.06

                                   LOSS DATA
   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00

                              UNIT HYDROGRAPH DATA
                         TP= 13.37     CP=0.82     NTA=   0

                                 RECESSION DATA
                  STRTQ=     0.00     QRCSN=     0.00     RTIOR= 1.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=17.56 AND R= 5.88 INTERVALS

      UNIT HYDROGRAPH 42 END-OF-PERIOD ORDINATES, LAG=  13.35 HOURS, CP= 0.82  VOL= 0.99
       18.       69.      137.      213.      292.      372.      452.      530.      607.      674.
      723.      755.      769.      769.      755.      726.      682.      612.      524.      442.
      373.      314.      265.      223.      188.      159.      134.      113.       95.       80.
       68.       57.       48.       40.       34.       29.       24.       20.       17.       14.
       12.       10.

                               END-OF-PERIOD FLOW
                          TIME    RAIN    EXCS    COMP Q
                             1    0.00    0.00        0.
```

| | | | |
|---|---|---|---|
| 2 | 0.00 | 0.00 | 0. |
| 3 | 0.00 | 0.00 | 0. |
| 4 | 0.02 | 0.02 | 0. |
| 5 | 0.04 | 0.04 | 2. |
| 6 | 0.06 | 0.06 | 6. |
| 7 | 0.07 | 0.07 | 15. |
| 8 | 0.06 | 0.06 | 28. |
| 9 | 0.06 | 0.06 | 46. |
| 10 | 0.06 | 0.06 | 69. |
| 11 | 0.06 | 0.06 | 97. |
| 12 | 0.07 | 0.07 | 130. |
| 13 | 1.46 | 1.46 | 194. |
| 14 | 2.03 | 2.03 | 343. |
| 15 | 2.71 | 2.71 | 632. |
| 16 | 7.11 | 7.11 | 1185. |
| 17 | 2.58 | 2.58 | 2075. |
| 18 | 2.00 | 2.00 | 3235. |
| 19 | 0.06 | 0.06 | 4565. |
| 20 | 0.06 | 0.06 | 5970. |
| 21 | 0.07 | 0.07 | 7397. |
| 22 | 0.06 | 0.06 | 8805. |
| 23 | 0.06 | 0.06 | 10151. |
| 24 | 0.06 | 0.06 | 11387. |
| 25 | 0.00 | 0.00 | 12440. |
| 26 | 0.00 | 0.00 | 13233. |
| 27 | 0.00 | 0.00 | 13734. |
| 28 | 0.00 | 0.00 | 13945. |
| 29 | 0.00 | 0.00 | 13879. |
| 30 | 0.00 | 0.00 | 13532. |
| 31 | 0.00 | 0.00 | 12896. |
| 32 | 0.00 | 0.00 | 11983. |
| 33 | 0.00 | 0.00 | 10798. |
| 34 | 0.00 | 0.00 | 9444. |
| 35 | 0.00 | 0.00 | 8100. |
| 36 | 0.00 | 0.00 | 6883. |
| 37 | 0.00 | 0.00 | 5832. |
| 38 | 0.00 | 0.00 | 4938. |
| 39 | 0.00 | 0.00 | 4177. |
| 40 | 0.00 | 0.00 | 3530. |
| 41 | 0.00 | 0.00 | 2980. |
| 42 | 0.00 | 0.00 | 2514. |
| 43 | 0.00 | 0.00 | 2121. |
| 44 | 0.00 | 0.00 | 1789. |
| 45 | 0.00 | 0.00 | 1509. |
| 46 | 0.00 | 0.00 | 1272. |
| 47 | 0.00 | 0.00 | 1073. |
| 48 | 0.00 | 0.00 | 904. |
| 49 | 0.00 | 0.00 | 762. |
| 50 | 0.00 | 0.00 | 642. |
| 51 | 0.00 | 0.00 | 541. |
| 52 | 0.00 | 0.00 | 456. |
| 53 | 0.00 | 0.00 | 384. |
| 54 | 0.00 | 0.00 | 323. |
| 55 | 0.00 | 0.00 | 260. |
| 56 | 0.00 | 0.00 | 201. |
| 57 | 0.00 | 0.00 | 146. |
| 58 | 0.00 | 0.00 | 60. |
| 59 | 0.00 | 0.00 | 28. |
| 60 | 0.00 | 0.00 | 6. |
| 61 | 0.00 | 0.00 | 4. |

| | | | |
|---|---|---|---|
| 63 | 0.00 | 0.00 | 2. |
| 64 | 0.00 | 0.00 | 1. |
| 65 | 0.00 | 0.00 | 0. |
| 66 | 0.00 | 0.00 | 0. |
| 67 | 0.00 | 0.00 | 0. |
| 68 | 0.00 | 0.00 | 0. |
| 69 | 0.00 | 0.00 | 0. |
| 70 | 0.00 | 0.00 | 0. |
| 71 | 0.00 | 0.00 | 0. |
| 72 | 0.00 | 0.00 | 0. |
| 73 | 0.00 | 0.00 | 0. |
| 74 | 0.00 | 0.00 | 0. |
| 75 | 0.00 | 0.00 | 0. |
| 76 | 0.00 | 0.00 | 0. |
| 77 | 0.00 | 0.00 | 0. |
| 78 | 0.00 | 0.00 | 0. |
| 79 | 0.00 | 0.00 | 0. |
| 80 | 0.00 | 0.00 | 0. |
| 81 | 0.00 | 0.00 | 0. |
| 82 | 0.00 | 0.00 | 0. |
| 83 | 0.00 | 0.00 | 0. |
| 84 | 0.00 | 0.00 | 0. |
| 85 | 0.00 | 0.00 | 0. |
| 86 | 0.00 | 0.00 | 0. |
| 87 | 0.00 | 0.00 | 0. |
| 88 | 0.00 | 0.00 | 0. |
| 89 | 0.00 | 0.00 | 0. |
| 90 | 0.00 | 0.00 | 0. |
| SUM | 18.76 | 18.76 | 233683. |

| | PEAK | 6-HOUR | 24-HOUR | 72-HOUR | TOTAL VOLUME |
|---|---|---|---|---|---|
| CFS | 13945. | 13536. | 8910. | 3245. | 233685. |
| INCHES | | 6.49 | 17.08 | 18.67 | 18.67 |
| AC-FT | | 6715. | 17682. | 19322. | 19322. |

RUNOFF MULTIPLIED BY 0.50

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0. | 0. | 0. | 0. | 1. | 3. | 7. | 14. | 23. | 34. |
| 48. | 65. | 97. | 171. | 316. | 592. | 1037. | 1617. | 2282. | 2985. |
| 3698. | 4402. | 5075. | 5693. | 6220. | 6616. | 6867. | 6972. | 6939. | 6766. |
| 6448. | 5991. | 5399. | 4722. | 4050. | 3441. | 2916. | 2469. | 2088. | 1765. |
| 1490. | 1257. | 1060. | 894. | 754. | 636. | 536. | 452. | 381. | 321. |
| 270. | 228. | 192. | 161. | 130. | 100. | 73. | 30. | 14. | 3. |
| 2. | 1. | 1. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |
| 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. | 0. |

| | PEAK | 6-HOUR | 24-HOUR | 72-HOUR | TOTAL VOLUME |
|---|---|---|---|---|---|
| CFS | 6972. | 6768. | 4455. | 1622. | 116842. |
| INCHES | | 3.24 | 8.54 | 9.33 | 9.33 |
| AC-FT | | 3357. | 8841. | 9661. | 9661. |

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE HALF OF PMF HYDROGRAPH THRU WOODCLIFF LAKE DAM

| ISTAQ | ICOMP | IECON | ITAPE | JPLT | JPRT | INAME |
|---|---|---|---|---|---|---|
| 5 | 1 | 0 | 0 | 0 | 0 | 1 |

ROUTING DATA

| QLOSS | CLOSS | AVG | IRES | ISAME |
|---|---|---|---|---|
| 0.0 | 0.000 | 0.00 | 1 | 0 |

| NSTPS | NSTDL | LAG | AMSKK | X | TSK | STORA |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0.000 | 0.000 | 0.000 | -1. |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| STORAGE= | 0. | 509. | 890. | 985. | 1080. | 1221. | 1362. | 1643. | 2064. | 2486. |
| OUTFLOW= | 0. | 1200. | 3000. | 3600. | 4900. | 7000. | 10000. | 18200. | 36000. | 61800. |

| TIME | EOP STOR | AVG IN | EOP OUT |
|---|---|---|---|
| 1 | 0. | 0. | 0. |
| 2 | 0. | 0. | 0. |
| 3 | 0. | 0. | 0. |
| 4 | 0. | 0. | 0. |
| 5 | 0. | 0. | 0. |
| 6 | 0. | 2. | 0. |
| 7 | 0. | 5. | 1. |
| 8 | 1. | 10. | 3. |
| 9 | 2. | 18. | 5. |
| 10 | 4. | 29. | 10. |
| 11 | 6. | 41. | 15. |
| 12 | 9. | 57. | 23. |
| 13 | 14. | 81. | 33. |
| 14 | 21. | 134. | 51. |
| 15 | 36. | 243. | 85. |
| 16 | 64. | 454. | 151. |
| 17 | 114. | 815. | 268. |
| 18 | 193. | 1327. | 456. |
| 19 | 306. | 1950. | 722. |
| 20 | 450. | 2633. | 1061. |
| 21 | 612. | 3342. | 1690. |
| 22 | 775. | 4050. | 2461. |
| 23 | 931. | 4739. | 3260. |
| 24 | 1053. | 5384. | 4541. |
| 25 | 1127. | 5956. | 5600. |
| 26 | 1168. | 6418. | 6223. |
| 27 | 1195. | 6741. | 6618. |
| 28 | 1210. | 6920. | 6848. |
| 29 | 1216. | 6956. | 6930. |
| 30 | 1212. | 6852. | 6871. |
| 31 | 1198. | 6607. | 6670. |
| 32 | 1175. | 6219. | 6327. |
| 33 | 1143. | 5695. | 5845. |
| 34 | 1103. | 5060. | 5247. |
| 35 | 1058. | 4386. | 4607. |
| 36 | 1013. | 3745. | 3985. |
| 37 | 967. | 3178. | 3486. |
| 38 | 915. | 2692. | 3158. |
| 39 | 855. | 2279. | 2837. |
| 40 | 792. | 1927. | 2540. |
| 41 | 729. | 1627. | 2242. |
| 42 | 669. | 1373. | 1958. |
| 43 | 614. | 1159. | 1697. |
| 44 | 564. | 977. | 1462. |
| 45 | 520. | 824. | 1253. |
| 46 | 479. | 695. | 1130. |
| 47 | 438. | 586. | 1033. |
| 48 | 397. | 494. | 937. |

| | | | |
|---|---|---|---|
| 49 | 358. | 416. | 845. |
| 50 | 321. | 351. | 757. |
| 51 | 286. | 296. | 675. |
| 52 | 254. | 249. | 600. |
| 53 | 225. | 210. | 530. |
| 54 | 198. | 176. | 468. |
| 55 | 174. | 145. | 410. |
| 56 | 152. | 115. | 358. |
| 57 | 131. | 86. | 310. |
| 58 | 112. | 51. | 264. |
| 59 | 93. | 22. | 221. |
| 60 | 77. | 8. | 183. |
| 61 | 64. | 2. | 151. |
| 62 | 52. | 2. | 124. |
| 63 | 43. | 1. | 102. |
| 64 | 35. | 0. | 84. |
| 65 | 29. | 0. | 69. |
| 66 | 24. | 0. | 57. |
| 67 | 20. | 0. | 47. |
| 68 | 16. | 0. | 38. |
| 69 | 13. | 0. | 31. |
| 70 | 11. | 0. | 26. |
| 71 | 9. | 0. | 21. |
| 72 | 7. | 0. | 17. |
| 73 | 6. | 0. | 14. |
| 74 | 5. | 0. | 12. |
| 75 | 4. | 0. | 9. |
| 76 | 3. | 0. | 8. |
| 77 | 2. | 0. | 6. |
| 78 | 2. | 0. | 5. |
| 79 | 1. | 0. | 4. |
| 80 | 1. | 0. | 3. |
| 81 | 1. | 0. | 3. |
| 82 | 1. | 0. | 2. |
| 83 | 0. | 0. | 2. |
| 84 | 0. | 0. | 1. |
| 85 | 0. | 0. | 1. |
| 86 | 0. | 0. | 1. |
| 87 | 0. | 0. | 0. |
| 88 | 0. | 0. | 0. |
| 89 | 0. | 0. | 0. |
| 90 | 0. | 0. | 0. |
| SUM | | | 116839. |

| | PEAK | 6-HOUR | 24-HOUR | 72-HOUR | TOTAL VOLUME |
|---|---|---|---|---|---|
| CFS | 6930. | 6711. | 4296. | 1622. | 116839. |
| INCHES | | 3.21 | 8.24 | 9.33 | 9.33 |
| AC-FT | | 3329. | 8526. | 9659. | 9661. |

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RUNOFF SUMMARY, AVERAGE FLOW

| | | PEAK | 6-HOUR | 24-HOUR | 72-HOUR | AREA |
|---|---|---|---|---|---|---|
| HYDROGRAPH AT | 5 | 6972. | 6768. | 4455. | 1622. | 19.40 |
| ROUTED TO | 5 | 6930. | 6711. | 4296. | 1622. | 19.40 |

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*****************************
HEC-1 VERSION DATED JAN 1973

*****************************

                    DAM SAFETY INSPECTION - NEW JERSEY
                          WOODCLIFF LAKE DAM
                              PMF ROUTING

                          JOB SPECIFICATION
          NQ    NHR   NMIN   IDAY    IHR   IMIN METRC   IPLT   IPRT NSTAN
          90      1      0      0      0      0      0      0      0      0
                                JOPER     NWT
                                    3       0

   **********     **********     **********     **********     **********

                      SUB-AREA RUNOFF COMPUTATION

                       INPUT SNYDER COEFFICIENTS

          ISTAQ  ICOMP  IECON  ITAPE   JPLT   JPRT  INAME
              5      0      0      0      0      0      1

                           HYDROGRAPH DATA
   IHYDG   IUHG  TAREA   SNAP  TRSDA  TRSPC  RATIO  ISNOW  ISAME  LOCAL
       0      1  19.40   0.00  19.40   0.00  0.000      0      0      0

                             PRECIP DATA
                        NP  STORM    DAJ    DAK
                        24   0.00   0.00   0.00
                            PRECIP PATTERN
    0.00      0.00      0.00      0.02      0.04      0.06      0.07      0.06      0.06      0.06
    0.06      0.07      1.46      2.03      2.71      7.11      2.58      2.00      0.06      0.06
    0.07      0.06      0.06      0.06

                               LOSS DATA
   STRKR  DLTKR  RTIOL  ERAIN  STRKS  RTIOK  STRTL  CNSTL  ALSMX  RTIMP
    0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00

                          UNIT HYDROGRAPH DATA
                     TP= 13.37     CP=0.82     NTA=   0

                             RECESSION DATA
                STRTQ=     0.00   QRCSN=    0.00   RTIOR= 1.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=17.56 AND R= 5.88 INTERVALS

        UNIT HYDROGRAPH 42 END-OF-PERIOD ORDINATES, LAG=  13.35 HOURS, CP= 0.82  VOL= 0.99
     18.       69.      137.      213.      292.      372.      452.      530.      607.      674.
    723.      755.      769.      769.      755.      726.      682.      612.      524.      442.
    373.      314.      265.      223.      188.      159.      134.      113.       95.       80.
     68.       57.       48.       40.       34.       29.       24.       20.       17.       14.
     12.       10.

                            END-OF-PERIOD FLOW
                       TIME   RAIN   EXCS    COMP Q
                          1   0.00   0.00        0.
```

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

| | | | |
|---|---|---|---|
| 2 | 0.00 | 0.00 | 0. |
| 3 | 0.00 | 0.00 | 0. |
| 4 | 0.02 | 0.02 | 0. |
| 5 | 0.04 | 0.04 | 2. |
| 6 | 0.06 | 0.06 | 6. |
| 7 | 0.07 | 0.07 | 15. |
| 8 | 0.06 | 0.06 | 28. |
| 9 | 0.06 | 0.06 | 46. |
| 10 | 0.06 | 0.06 | 69. |
| 11 | 0.06 | 0.06 | 97. |
| 12 | 0.07 | 0.07 | 130. |
| 13 | 1.46 | 1.46 | 194. |
| 14 | 2.03 | 2.03 | 343. |
| 15 | 2.71 | 2.71 | 632. |
| 16 | 7.11 | 7.11 | 1185. |
| 17 | 2.58 | 2.58 | 2075. |
| 18 | 2.00 | 2.00 | 3235. |
| 19 | 0.06 | 0.06 | 4565. |
| 20 | 0.06 | 0.06 | 5970. |
| 21 | 0.07 | 0.07 | 7397. |
| 22 | 0.06 | 0.06 | 8805. |
| 23 | 0.06 | 0.06 | 10151. |
| 24 | 0.06 | 0.06 | 11387. |
| 25 | 0.00 | 0.00 | 12440. |
| 26 | 0.00 | 0.00 | 13233. |
| 27 | 0.00 | 0.00 | 13734. |
| 28 | 0.00 | 0.00 | 13945. |
| 29 | 0.00 | 0.00 | 13879. |
| 30 | 0.00 | 0.00 | 13532. |
| 31 | 0.00 | 0.00 | 12896. |
| 32 | 0.00 | 0.00 | 11983. |
| 33 | 0.00 | 0.00 | 10798. |
| 34 | 0.00 | 0.00 | 9444. |
| 35 | 0.00 | 0.00 | 0100. |
| 36 | 0.00 | 0.00 | 6883. |
| 37 | 0.00 | 0.00 | 5832. |
| 38 | 0.00 | 0.00 | 4938. |
| 39 | 0.00 | 0.00 | 4177. |
| 40 | 0.00 | 0.00 | 3530. |
| 41 | 0.00 | 0.00 | 2980. |
| 42 | 0.00 | 0.00 | 2514. |
| 43 | 0.00 | 0.00 | 2121. |
| 44 | 0.00 | 0.00 | 1789. |
| 45 | 0.00 | 0.00 | 1509. |
| 46 | 0.00 | 0.00 | 1272. |
| 47 | 0.00 | 0.00 | 1073. |
| 48 | 0.00 | 0.00 | 904. |
| 49 | 0.00 | 0.00 | 762. |
| 50 | 0.00 | 0.00 | 642. |
| 51 | 0.00 | 0.00 | 541. |
| 52 | 0.00 | 0.00 | 456. |
| 53 | 0.00 | 0.00 | 384. |
| 54 | 0.00 | 0.00 | 323. |
| 55 | 0.00 | 0.00 | 260. |
| 56 | 0.00 | 0.00 | 201. |
| 57 | 0.00 | 0.00 | 146. |
| 58 | 0.00 | 0.00 | 60. |
| 59 | 0.00 | 0.00 | 28. |
| 60 | 0.00 | 0.00 | 6. |
| 61 | 0.00 | 0.00 | 4. |
| 62 | 0.00 | 0.00 | 3. |

| | | | |
|---|---|---|---|
| 63 | 0.00 | 0.00 | 2. |
| 64 | 0.00 | 0.00 | 1. |
| 65 | 0.00 | 0.00 | 0. |
| 66 | 0.00 | 0.00 | 0. |
| 67 | 0.00 | 0.00 | 0. |
| 68 | 0.00 | 0.00 | 0. |
| 69 | 0.00 | 0.00 | 0. |
| 70 | 0.00 | 0.00 | 0. |
| 71 | 0.00 | 0.00 | 0. |
| 72 | 0.00 | 0.00 | 0. |
| 73 | 0.00 | 0.00 | 0. |
| 74 | 0.00 | 0.00 | 0. |
| 75 | 0.00 | 0.00 | 0. |
| 76 | 0.00 | 0.00 | 0. |
| 77 | 0.00 | 0.00 | 0. |
| 78 | 0.00 | 0.00 | 0. |
| 79 | 0.00 | 0.00 | 0. |
| 80 | 0.00 | 0.00 | 0. |
| 81 | 0.00 | 0.00 | 0. |
| 82 | 0.00 | 0.00 | 0. |
| 83 | 0.00 | 0.00 | 0. |
| 84 | 0.00 | 0.00 | 0. |
| 85 | 0.00 | 0.00 | 0. |
| 86 | 0.00 | 0.00 | 0. |
| 87 | 0.00 | 0.00 | 0. |
| 88 | 0.00 | 0.00 | 0. |
| 89 | 0.00 | 0.00 | 0. |
| 90 | 0.00 | 0.00 | 0. |
| SUM | 18.76 | 18.76 | 233683. |

| | PEAK | 6-HOUR | 24-HOUR | 72-HOUR | TOTAL VOLUME |
|---|---|---|---|---|---|
| CFS | 13945. | 13536. | 8910. | 3245. | 233685. |
| INCHES | | 6.49 | 17.08 | 18.67 | 18.67 |
| AC-FT | | 6715. | 17682. | 19322. | 19322. |

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HYDROGRAPH ROUTING

ROUTE PMF HYDROGRAPH THRU WOODCLIFF LAKE DAM

| ISTAQ | ICOMP | IECON | ITAPE | JPLT | JPRT | INAME |
|---|---|---|---|---|---|---|
| 5 | 1 | 0 | 0 | 2 | 0 | 1 |

ROUTING DATA

| QLOSS | CLOSS | AVG | IRES | ISAME |
|---|---|---|---|---|
| 0.0 | 0.000 | 0.00 | 1 | 0 |

| NSTPS | NSTDL | LAG | AMSKK | X | TSK | STORA |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0.000 | 0.000 | 0.000 | -1. |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| STORAGE= | 0. | 509. | 890. | 985. | 1080. | 1221. | 1361. | 1643. | 2064. | 2486. |
| OUTFLOW= | 0. | 1200. | 3000. | 3600. | 4900. | 7000. | 10000. | 18200. | 36000. | 61800. |

| TIME | EOP STOR | AVG IN | EOP OUT |
|---|---|---|---|
| 1 | 0. | 0. | 0. |
| 2 | 0. | 0. | 0. |
| 3 | 0. | 0. | 0. |

| | | | |
|---|---|---|---|
| 5 | 0. | 1. | 0. |
| 6 | 0. | 4. | 0. |
| 7 | 1. | 10. | 2. |
| 8 | 2. | 21. | 6. |
| 9 | 4. | 37. | 11. |
| 10 | 8. | 58. | 20. |
| 11 | 13. | 83. | 31. |
| 12 | 19. | 114. | 46. |
| 13 | 28. | 162. | 66. |
| 14 | 43. | 269. | 102. |
| 15 | 72. | 487. | 171. |
| 16 | 128. | 908. | 302. |
| 17 | 228. | 1630. | 537. |
| 18 | 387. | 2655. | 913. |
| 19 | 604. | 3900. | 1648. |
| 20 | 854. | 5267. | 2831. |
| 21 | 1084. | 6684. | 4966. |
| 22 | 1241. | 8101. | 7437. |
| 23 | 1330. | 9478. | 9354. |
| 24 | 1388. | 10769. | 10794. |
| 25 | 1430. | 11913. | 12016. |
| 26 | 1461. | 12836. | 12911. |
| 27 | 1482. | 13483. | 13536. |
| 28 | 1494. | 13840. | 13867. |
| 29 | 1495. | 13912. | 13916. |
| 30 | 1487. | 13705. | 13686. |
| 31 | 1470. | 13214. | 13171. |
| 32 | 1442. | 12439. | 12372. |
| 33 | 1405. | 11391. | 11301. |
| 34 | 1361. | 10121. | 10013. |
| 35 | 1307. | 8772. | 8846. |
| 36 | 1247. | 7491. | 7574. |
| 37 | 1190. | 6357. | 6538. |
| 38 | 1131. | 5305. | 5659. |
| 39 | 1074. | 4556. | 4824. |
| 40 | 1023. | 3854. | 4123. |
| 41 | 975. | 3255. | 3540. |
| 42 | 923. | 2747. | 3212. |
| 43 | 863. | 2318. | 2875. |
| 44 | 800. | 1955. | 2574. |
| 45 | 736. | 1649. | 2272. |
| 46 | 675. | 1391. | 1984. |
| 47 | 618. | 1173. | 1719. |
| 48 | 568. | 989. | 1480. |
| 49 | 523. | 833. | 1269. |
| 50 | 482. | 702. | 1137. |
| 51 | 441. | 592. | 1040. |
| 52 | 400. | 498. | 944. |
| 53 | 361. | 420. | 851. |
| 54 | 323. | 353. | 762. |
| 55 | 288. | 291. | 679. |
| 56 | 254. | 230. | 599. |
| 57 | 222. | 173. | 524. |
| 58 | 190. | 103. | 449. |
| 59 | 160. | 44. | 377. |
| 60 | 132. | 17. | 313. |
| 61 | 109. | 5. | 258. |
| 62 | 90. | 4. | 213. |
| 63 | 74. | 2. | 176. |
| 64 | 61. | 1. | 145. |

| | | | |
|---|---|---|---|
| 65 | 50. | 0. | 119. |
| 66 | 41. | 0. | 98. |
| 67 | 34. | 0. | 80. |
| 68 | 28. | 0. | 66. |
| 69 | 23. | 0. | 54. |
| 70 | 19. | 0. | 45. |
| 71 | 15. | 0. | 37. |
| 72 | 12. | 0. | 30. |
| 73 | 10. | 0. | 25. |
| 74 | 8. | 0. | 20. |
| 75 | 7. | 0. | 16. |
| 76 | 5. | 0. | 13. |
| 77 | 4. | 0. | 11. |
| 78 | 3. | 0. | 9. |
| 79 | 3. | 0. | 7. |
| 80 | 2. | 0. | 6. |
| 81 | 2. | 0. | 5. |
| 82 | 1. | 0. | 4. |
| 83 | 1. | 0. | 3. |
| 84 | 1. | 0. | 2. |
| 85 | 1. | 0. | 2. |
| 86 | 0. | 0. | 1. |
| 87 | 0. | 0. | 1. |
| 88 | 0. | 0. | 1. |
| 89 | 0. | 0. | 1. |
| 90 | 0. | 0. | 0. |
| SUM | | | 233680. |

| | PEAK | 6-HOUR | 24-HOUR | 72-HOUR | TOTAL VOLUME |
|---|---|---|---|---|---|
| CFS | 13916. | 13515. | 8723. | 3245. | 233680. |
| INCHES | | 6.48 | 16.73 | 18.67 | 18.67 |
| AC-FT | | 6705. | 17312. | 19319. | 19322. |

WOOD CLIFF LAKE DAM — SHEET NO. 1 OF 3
RESERVOIR EVACUATION — JOB NO. 1209-001-1
BY KLB DATE 7-11-79



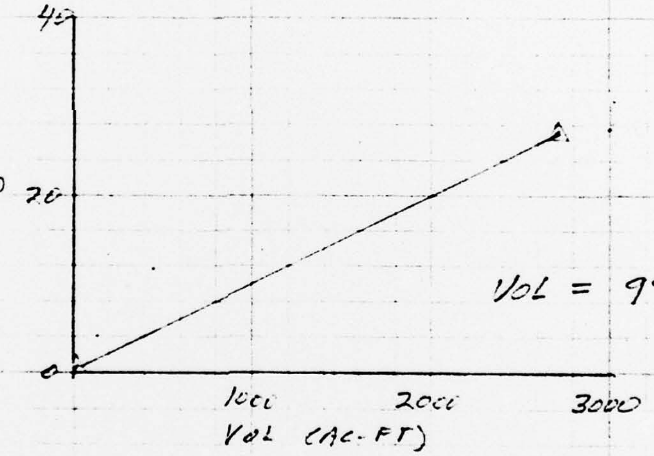
a) DISCHARGE VS. HEAD (FROM PREVIOUS WORK)

$$Q = 100.79\sqrt{H} \qquad 67 \leq H \leq 94.33$$

b) STORAGE VS. HEAD

ASSUME STRAIGHT LINE RELATIONSHIP FROM NORMAL WATER SURFACE VOLUME TO ZERO VOLUME AT ZERO HEAD.

| | ELEV (FT) | HEAD (FT) | VOL. (AC-FT) |
|---|---|---|---|
| N.W.S. | 94.33 | 27.33 | 2729 |
| TOP OF OUTLET PIPE | 67.00 | 0 | 0 |




VOL = 99.85 h

c) DRAINAGE AREA = 19.4 SQ. mi

INFLOW = 2 CFS/SQ mi = 2 X 19.4 = 38.8 CFS

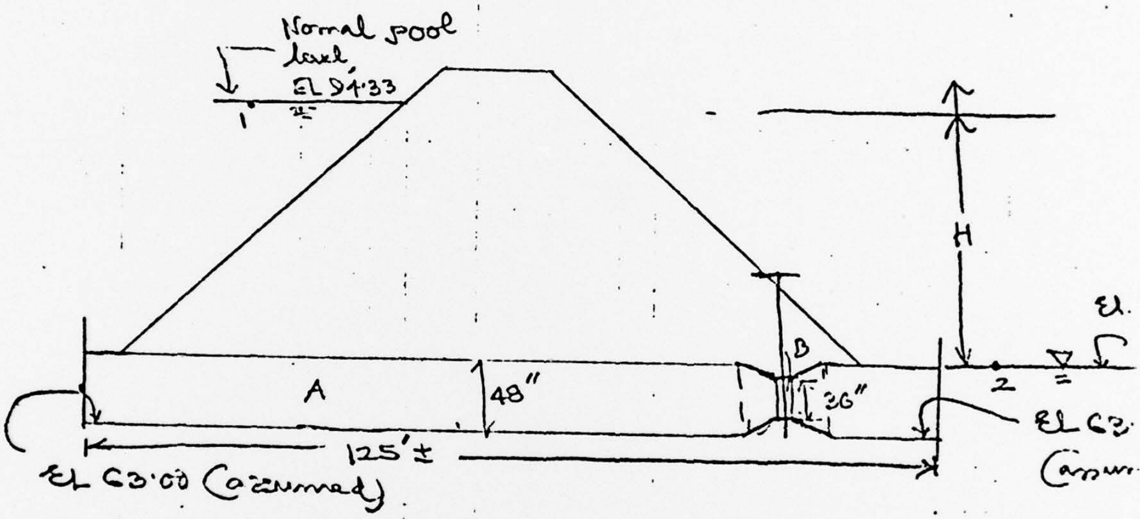
d) WITH CONSTANT INFLOW
RESERVOIR EVACUATION TIME = 134 HR
(FROM COMPUTER PRINTOUT)
= 5.58 DAYS

e) RESERVOIR EVACUATION TIME (0 INFLOW) = 108 HR
= 4.50 DAYS

WOODCLIFF LAKE DAM

Outlet Works:

1. Dimensions (from drawings, dated Aug. 1903)




2. Determination of Outlet Capacity

Assumptions:

1. Gate fully open
2. Outlet submerged to the top of pipe

Solution:

Apply energy eqn. between 1 & 2.

$$H = \underline{\underline{K_e}} \frac{V_A^2}{2g} + f\frac{L}{D} \cdot \frac{V_A^2}{2g} + \underline{\underline{K_c}}\left(\frac{V_B^2}{2g} - \frac{V_A^2}{2g}\right)$$

$$+ \underline{\underline{K_g}} \frac{V_B^2}{2g} + K_{ex}\left(\frac{V_B^2}{2g} - \frac{V_A^2}{2g}\right) + \frac{V_A^2}{2g}$$

Now

$K_e = 0.5$ assuming square edge

$K_c = 0.1$ for gradual contraction

$K_{ex} = 0.1$

$K_g = 0.19$ assuming wide open gate valve.

$$V_B A_B = V_A A_A$$

$$V_B 3^2 = V_A 4^2 \Rightarrow V_B = \frac{16}{9} V_A = 1.78 V_A$$

$$\therefore H = 0.5 \frac{V_A^2}{2g} + \frac{fL}{D} \cdot \frac{V_A^2}{2g} + .1\left(\frac{1.78^2 V_A^2}{2g} - \frac{V_A^2}{2g}\right) \times 2$$

$$+ 0.19\left(1.78^2 \frac{V_A^2}{2g}\right) + \frac{V_A^2}{2g}$$

$$= \left[0.5 + \frac{fL}{D} + 0.2 \times 2.16 + .19 \times 3.16 + 1\right] \frac{V_A^2}{2g}$$

$$= \left(2.53 + \frac{fL}{D}\right) \frac{V_A^2}{2g}$$

NEW JERSEY DAM SAFETY INSPECTION — SHEET NO. 3 OF 3

WOODCLIFF LAKE DAM — JOB NO. 1269-001

OUTLET CAPACITY — BY MAS DATE 6-6-

Assuming rough concrete pipe,

$$\epsilon = .01$$

$$\frac{\epsilon}{D} = \frac{.01}{4} = 0.0025$$

$$\Rightarrow f = .0145 \quad \text{(for Complete turbulence)}$$

∴ Thus

$$H = \left(2.53 + \frac{.0145 \times 125}{4}\right)\frac{V_A^2}{2g} = 2.98\frac{V_A^2}{2g}$$

$$V_A = \sqrt{\frac{1}{2.98}}\sqrt{2gH} = 0.58\sqrt{2gH}$$

$$Q = 0.58A\sqrt{2gH}$$

$$V = \frac{Q}{A} = \frac{527}{.785 \times 4^2} = 42$$

$$R = 42 \times 4 \times 10^5 = 1.68 \times$$

O.K. Complete turbulence

| Water Surface Elevation behind dam | H feet | $Q = 0.58A\sqrt{2gH}$ $= 100.79\sqrt{H}$ |
|---|---|---|
| 94.33 | 27.33 | 527 |
| 96 | 29.00 | 543 |
| 98 | 31.00 | 561 |
| 100 | 33.00 | 579 |
| 102 | 35.00 | 596 |
| 104 | 37.00 | 613 |
| 106 | 39.00 | 629 |
| 108 | 41.00 | 645 |

Top of dam El. 100

Assume dam will be raised

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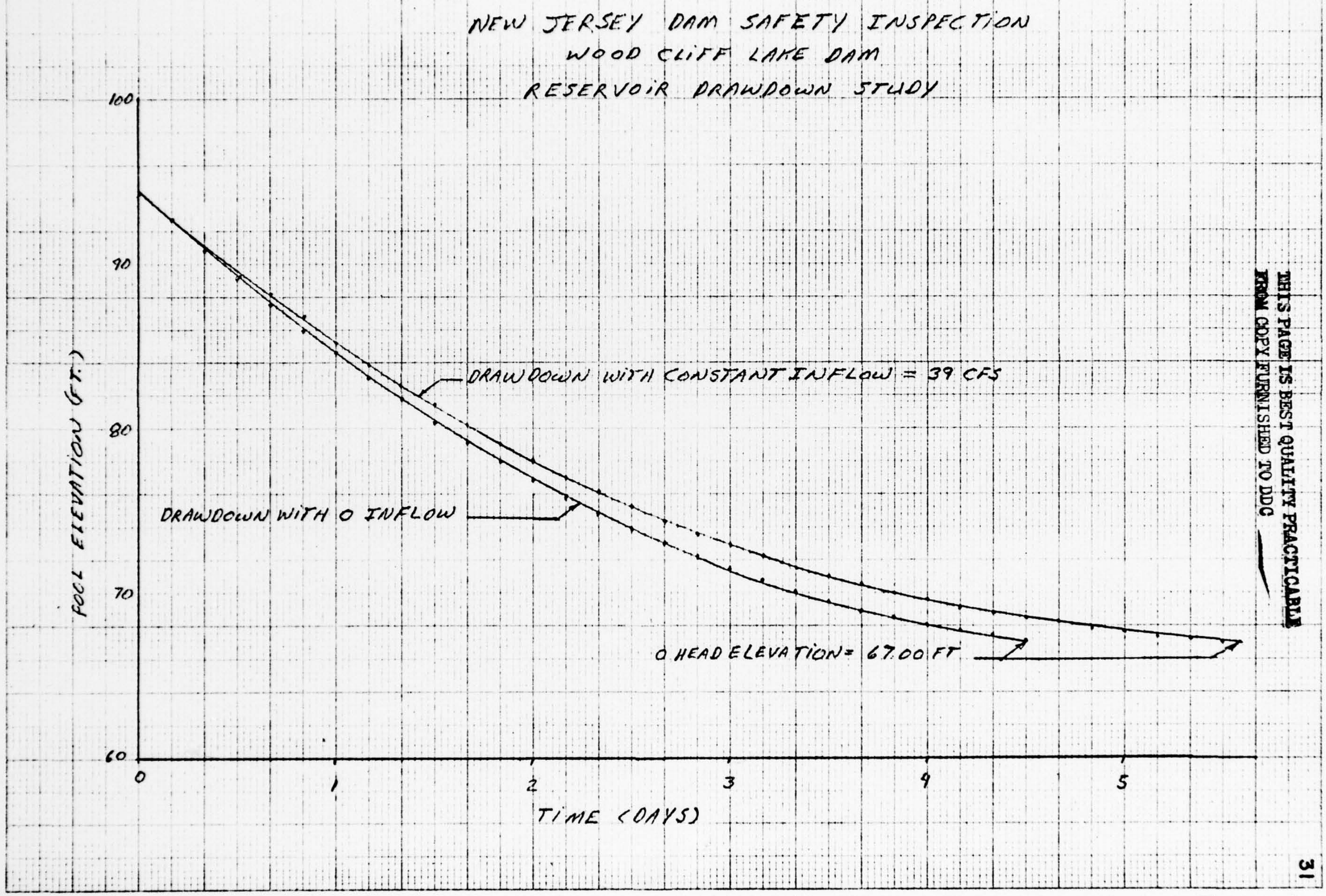

NEW JERSEY DAM SAFETY INSPECTION
WOOD CLIFF LAKE DAM
RESERVOIR DRAWDOWN STUDY
POOL ELEVATION (FT.)
100
90
80
70
60
0
1
2
3
4
5
TIME (DAYS)
DRAWDOWN WITH CONSTANT INFLOW = 39 CFS
DRAWDOWN WITH 0 INFLOW
0 HEAD ELEVATION = 67.00 FT


7-19-78

FLOOD ROUTING STUDY
*******************



WOODCLIFF LAKE DAM RESERVOIR DRAWDOWN STUDY (DA = 19.4 SQ. MI.)

1.0000 UNREGULATED DIVERSION CONDUIT AT ELEV 67.00 FT

MAXIMUM OPERATION LEVEL AT ELEV 94.33 FT (FROM OPERAT
MINIMUM OPERATION LEVEL AT ELEV 67.00 FT

ROUTING STARTS AT ELEV 94.33 FT, ENDS AT ELEV 67.00 FT

| TIME DAY | TIME HR | AVG. INFLOW CFS | RESERVOIR EL FT | MAIN SPILLWAY DISCHARGE CFS | OVERFLOW SPILLWAY DISCHARGE CFS | Outlet DISCHARGE CFS |
|---|---|---|---|---|---|---|
| 0 | 0 | | 94.33 | | | |
| | | 0. | | | | |
| 0 | 2 | | 93.43 | 0. | 0. | 518. |
| | | 0. | | | | |
| 0 | 4 | | 92.54 | 0. | 0. | 510. |
| | | 0. | | | | |
| 0 | 6 | | 91.66 | 0. | 0. | 501. |
| | | 0. | | | | |
| 0 | 8 | | 90.80 | 0. | 0. | 492. |
| | | 0. | | | | |
| 0 | 10 | | 89.96 | 0. | 0. | 483. |
| | | 0. | | | | |
| 0 | 12 | | 89.13 | 0. | 0. | 474. |
| | | 0. | | | | |
| 0 | 14 | | 88.32 | 0. | 0. | 466. |
| | | 0. | | | | |
| 0 | 16 | | 87.52 | 0. | 0. | 457. |
| | | 0. | | | | |
| 0 | 18 | | 86.74 | 0. | 0. | 448. |
| | | 0. | | | | |
| 0 | 20 | | 85.97 | 0. | 0. | 439. |
| | | 0. | | | | |
| 0 | 22 | | 85.22 | 0. | 0. | 430. |
| | | 0. | | | | |
| 1 | 0 | | 84.48 | 0. | 0. | 421. |
| | | 0. | | | | |
| 1 | 2 | | 83.76 | 0. | 0. | 413. |
| | | 0. | | | | |
| 1 | 4 | | 83.05 | 0. | 0. | 404. |
| | | 0. | | | | |
| 1 | 6 | | 82.36 | 0. | 0. | 396. |
| | | 0. | | | | |
| 1 | 8 | | 81.68 | 0. | 0. | 387. |
| | | 0. | | | | |
| 1 | 10 | | 81.02 | 0. | 0. | 373. |

# FLOOD ROUTING STUDY

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PAGE

| TIME DAY | HR | AVG. INFLOW CFS | RESERVOIR EL FT | MAIN SPILLWAY DISCHARGE CFS | OVERFLOW SPILLWAY DISCHARGE CFS | Outlet DISCHARGE CFS |
|---|---|---|---|---|---|---|
| 1 | 12 | 0. | 80.37 | 0. | 0. | 369. |
| 1 | 14 | 0. | 79.74 | 0. | 0. | 360. |
| 1 | 16 | 0. | 79.13 | 0. | 0. | 351. |
| 1 | 18 | 0. | 78.53 | 0. | 0. | 344. |
| 1 | 20 | 0. | 77.94 | 0. | 0. | 335. |
| 1 | 22 | 0. | 77.37 | 0. | 0. | 327. |
| 2 | 0 | 0. | 76.81 | 0. | 0. | 318. |
| 2 | 2 | 0. | 76.27 | 0. | 0. | 309. |
| 2 | 4 | 0. | 75.74 | 0. | 0. | 300. |
| 2 | 6 | 0. | 75.23 | 0. | 0. | 290. |
| 2 | 8 | 0. | 74.74 | 0. | 0. | 281. |
| 2 | 10 | 0. | 74.26 | 0. | 0. | 271. |
| 2 | 12 | 0. | 73.80 | 0. | 0. | 262. |
| 2 | 14 | 0. | 73.35 | 0. | 0. | 252. |
| 2 | 16 | 0. | 72.92 | 0. | 0. | 243. |
| 2 | 18 | 0. | 72.51 | 0. | 0. | 234. |
| 2 | 20 | 0. | 72.11 | 0. | 0. | 224. |
| 2 | 22 | 0. | 71.73 | 0. | 0. | 215. |
| 3 | 0 | 0. | 71.37 | 0. | 0. | 207. |
| 3 | 2 | 0. | 71.02 | 0. | 0. | 198. |
| 3 | 4 | 0. | 70.68 | 0. | 0. | 190. |
| 3 | 6 | 0. | 70.36 | 0. | 0. | 181. |
| 3 | 8 | 0. | 70.05 | 0. | 0. | 173. |

FLOOD ROUTING STUDY
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PAGE

| TIME | | AVG. INFLOW | RESERVOIR EL | MAIN SPILLWAY DISCHARGE | OVERFLOW SPILLWAY DISCHARGE | Outlet DISCHARGE |
|---|---|---|---|---|---|---|
| DAY | HR | CFS | FT | CFS | CFS | CFS |
| 3 | 10 | 0. | 69.76 | 0. | 0. | 166. |
| 3 | 12 | 0. | 69.48 | 0. | 0. | 158. |
| 3 | 14 | 0. | 69.21 | 0. | 0. | 151. |
| 3 | 16 | 0. | 68.96 | 0. | 0. | 143. |
| 3 | 18 | 0. | 68.72 | 0. | 0. | 137. |
| 3 | 20 | 0. | 68.49 | 0. | 0. | 130. |
| 3 | 22 | 0. | 68.27 | 0. | 0. | 124. |
| 4 | 0 | 0. | 68.06 | 0. | 0. | 118. |
| 4 | 2 | 0. | 67.86 | 0. | 0. | 113. |
| 4 | 4 | 0. | 67.67 | 0. | 0. | 107. |
| 4 | 6 | 0. | 67.49 | 0. | 0. | 102. |
| 4 | 8 | 0. | 67.31 | 0. | 0. | 97. |
| 4 | 10 | 0. | 67.15 | 0. | 0. | 93. |
| 4 | 12 | 0. | 67.00 | 0. | 0. | 88. |

************************************************************************

RESERVOIR ELEVATION WENT UNDER MINIMUM WATERSURFACE ELEVATION
AFTER 4 DAYS AND 12 HOURS.

TOTAL INFLOW VOLUME 0. ACFT
TOTAL DISCHARGE VOLUME 2730. ACFT

MAXIMUM WATER SURFACE ELEVATION 94.33 FT

MAXIMUM DISCHARGE THRU DIVERSION CONDUIT 518. CFS

MAXIMUM TOTAL INFLOW 0. CFS
MAXIMUM TOTAL DISCHARGE 527. CFS

WOODCLIFF LAKE DAM RESERVOIR DRAWDOWN STUDY (DA = 19.4 SQ. MI.)

1.0000 UNREGULATED DIVERSION CONDUIT AT ELEV 67.00 FT

MAXIMUM OPERATION LEVEL AT ELEV 94.33 FT (FROM OPERAT
MINIMUM OPERATION LEVEL AT ELEV 67.00 FT

ROUTING STARTS AT ELEV 94.33 FT, ENDS AT ELEV 67.00 FT

| TIME DAY | TIME HR | AVG. INFLOW CFS | RESERVOIR EL FT | MAIN SPILLWAY DISCHARGE CFS | OVERFLOW SPILLWAY DISCHARGE CFS | Outlet DISCHARGE CFS |
|---|---|---|---|---|---|---|
| 0 | 0 | | 94.33 | | | |
| | | 39. | | | | |
| 0 | 2 | | 93.49 | 0. | 0. | 519. |
| | | 39. | | | | |
| 0 | 4 | | 92.67 | 0. | 0. | 511. |
| | | 39. | | | | |
| 0 | 6 | | 91.86 | 0. | 0. | 503. |
| | | 39. | | | | |
| 0 | 8 | | 91.06 | 0. | 0. | 495. |
| | | 39. | | | | |
| 0 | 10 | | 90.28 | 0. | 0. | 486. |
| | | 39. | | | | |
| 0 | 12 | | 89.51 | 0. | 0. | 478. |
| | | 39. | | | | |
| 0 | 14 | | 88.76 | 0. | 0. | 470. |
| | | 39. | | | | |
| 0 | 16 | | 88.02 | 0. | 0. | 462. |
| | | 39. | | | | |
| 0 | 18 | | 87.29 | 0. | 0. | 454. |
| | | 39. | | | | |
| 0 | 20 | | 86.58 | 0. | 0. | 446. |
| | | 39. | | | | |
| 0 | 22 | | 85.88 | 0. | 0. | 438. |
| | | 39. | | | | |
| 1 | 0 | | 85.20 | 0. | 0. | 430. |
| | | 39. | | | | |
| 1 | 2 | | 84.53 | 0. | 0. | 422. |
| | | 39. | | | | |
| 1 | 4 | | 83.87 | 0. | 0. | 414. |
| | | 39. | | | | |
| 1 | 6 | | 83.23 | 0. | 0. | 407. |
| | | 39. | | | | |
| 1 | 8 | | 82.60 | 0. | 0. | 399. |
| | | 39. | | | | |
| 1 | 10 | | 81.98 | 0. | 0. | 391. |

# FLOOD ROUTING STUDY

*******************

| TIME DAY | TIME HR | AVG. INFLOW CFS | RESERVOIR EL FT | MAIN SPILLWAY DISCHARGE CFS | OVERFLOW SPILLWAY DISCHARGE CFS | Outlet DISCHARGE CFS |
|---|---|---|---|---|---|---|
| | | 39. | | | | |
| 1 | 12 | | 81.38 | 0. | 0. | 383. |
| | | 39. | | | | |
| 1 | 14 | | 80.79 | 0. | 0. | 375. |
| | | 39. | | | | |
| 1 | 16 | | 80.22 | 0. | 0. | 367. |
| | | 39. | | | | |
| 1 | 18 | | 79.66 | 0. | 0. | 359. |
| | | 39. | | | | |
| 1 | 20 | | 79.11 | 0. | 0. | 351. |
| | | 39. | | | | |
| 1 | 22 | | 78.58 | 0. | 0. | 344. |
| | | 39. | | | | |
| 2 | 0 | | 78.05 | 0. | 0. | 337. |
| | | 39. | | | | |
| 2 | 2 | | 77.55 | 0. | 0. | 329. |
| | | 39. | | | | |
| 2 | 4 | | 77.05 | 0. | 0. | 322. |
| | | 39. | | | | |
| 2 | 6 | | 76.57 | 0. | 0. | 314. |
| | | 39. | | | | |
| 2 | 8 | | 76.10 | 0. | 0. | 306. |
| | | 39. | | | | |
| 2 | 10 | | 75.64 | 0. | 0. | 298. |
| | | 39. | | | | |
| 2 | 12 | | 75.20 | 0. | 0. | 290. |
| | | 39. | | | | |
| 2 | 14 | | 74.77 | 0. | 0. | 282. |
| | | 39. | | | | |
| 2 | 16 | | 74.36 | 0. | 0. | 274. |
| | | 39. | | | | |
| 2 | 18 | | 73.96 | 0. | 0. | 265. |
| | | 39. | | | | |
| 2 | 20 | | 73.58 | 0. | 0. | 257. |
| | | 39. | | | | |
| 2 | 22 | | 73.21 | 0. | 0. | 249. |
| | | 39. | | | | |
| 3 | 0 | | 72.85 | 0. | 0. | 241. |
| | | 39. | | | | |
| 3 | 2 | | 72.50 | 0. | 0. | 233. |
| | | 39. | | | | |
| 3 | 4 | | 72.17 | 0. | 0. | 226. |
| | | 39. | | | | |
| 3 | 6 | | 71.86 | 0. | 0. | 218. |
| | | 39. | | | | |
| 3 | 8 | | 71.55 | 0. | 0. | 211. |

| TIME DAY | HR | AVG. INFLOW CFS | RESERVOIR EL FT | MAIN SPILLWAY DISCHARGE CFS | OVERFLOW SPILLWAY DISCHARGE CFS | Outlet DISCHARGE CFS |
|---|---|---|---|---|---|---|
| | | 39. | | | | |
| 3 | 10 | | 71.26 | 0. | 0. | 204. |
| | | 39. | | | | |
| 3 | 12 | | 70.98 | 0. | 0. | 197. |
| | | 39. | | | | |
| 3 | 14 | | 70.71 | 0. | 0. | 190. |
| | | 39. | | | | |
| 3 | 16 | | 70.46 | 0. | 0. | 184. |
| | | 39. | | | | |
| 3 | 18 | | 70.21 | 0. | 0. | 177. |
| | | 39. | | | | |
| 3 | 20 | | 69.98 | 0. | 0. | 171. |
| | | 39. | | | | |
| 3 | 22 | | 69.75 | 0. | 0. | 165. |
| | | 39. | | | | |
| 4 | 0 | | 69.54 | 0. | 0. | 159. |
| | | 39. | | | | |
| 4 | 2 | | 69.33 | 0. | 0. | 154. |
| | | 39. | | | | |
| 4 | 4 | | 69.14 | 0. | 0. | 148. |
| | | 39. | | | | |
| 4 | 6 | | 68.95 | 0. | 0. | 143. |
| | | 39. | | | | |
| 4 | 8 | | 68.78 | 0. | 0. | 138. |
| | | 39. | | | | |
| 4 | 10 | | 68.61 | 0. | 0. | 134. |
| | | 39. | | | | |
| 4 | 12 | | 68.45 | 0. | 0. | 129. |
| | | 39. | | | | |
| 4 | 14 | | 68.30 | 0. | 0. | 125. |
| | | 39. | | | | |
| 4 | 16 | | 68.15 | 0. | 0. | 121. |
| | | 39. | | | | |
| 4 | 18 | | 68.01 | 0. | 0. | 117. |
| | | 39. | | | | |
| 4 | 20 | | 67.88 | 0. | 0. | 113. |
| | | 39. | | | | |
| 4 | 22 | | 67.75 | 0. | 0. | 110. |
| | | 39. | | | | |
| 5 | 0 | | 67.63 | 0. | 0. | 106. |
| | | 39. | | | | |
| 5 | 2 | | 67.52 | 0. | 0. | 103. |
| | | 39. | | | | |
| 5 | 4 | | 67.41 | 0. | 0. | 100. |
| | | 39. | | | | |
| 5 | 6 | | 67.31 | 0. | 0. | 97. |

| TIME DAY | TIME HR | AVG.INFLOW CFS | RESERVOIR EL FT | MAIN SPILLWAY DISCHARGE CFS | OVERFLOW SPILLWAY DISCHARGE CFS | Outlet DISCHARGE CFS |
|---|---|---|---|---|---|---|
| | | 39. | | | | |
| 5 | 8 | | 67.21 | 0. | 0. | 94. |
| | | 39. | | | | |
| 5 | 10 | | 67.11 | 0. | 0. | 92. |
| | | 39. | | | | |
| 5 | 12 | | 67.02 | 0. | 0. | 89. |
| | | 39. | | | | |
| 5 | 14 | | 67.00 | 0. | 0. | 87. |

*******************************************************************************

RESERVOIR ELEVATION WENT UNDER MINIMUM WATERSURFACE ELEVATION
AFTER 5 DAYS AND 14 HOURS.

| | | |
|---|---|---|
| TOTAL INFLOW VOLUME | 449. | ACFT |
| TOTAL DISCHARGE VOLUME | 3184. | ACFT |
| MAXIMUM WATER SURFACE ELEVATION | 94.33 | FT |
| MAXIMUM DISCHARGE THRU DIVERSION CONDUIT | 519. | CFS |
| MAXIMUM TOTAL INFLOW | 39. | CFS |
| MAXIMUM TOTAL DISCHARGE | 527. | CFS |

Um

PMP RAINFALL DERIVATION (MAX 24 HOURS)

DISTRIBUTION ACCORDING TO EC 1110-2-163



| TIME (HR) | TOTAL 24 HR % | TOTAL RAINFALL DEPTH (INCH) | INCREMENTAL RAINFALL DEPTH (INCH) | DIRECT RUNOFF (PMF) ACCUM. (INCH) | DIRECT RUNOFF (PMF) INCREMENTAL (INCH) | INCREMENTAL LOSS (INCH) |
|---|---|---|---|---|---|---|
| 1 | 0.81 | 0.18 | 0.18 | 0 | 0 | 0.18 |
| 2 | 1.61 | 0.36 | 0.18 | 0 | 0.00 | 0.18 |
| 3 | 2.42 | 0.55 | 0.19 | 0 | 0.00 | 0.19 |
| 4 | 3.23 | 0.73 | 0.18 | 0.02 | 0.02 | 0.16 |
| 5 | 4.04 | 0.91 | 0.18 | 0.06 | 0.04 | 0.14 |
| 6 | 4.84 | 1.09 | 0.18 | 0.11 | 0.06 | 0.12* |
| 7 | 5.65 | 1.28 | 0.19 | 0.19 | 0.07 | 0.12 |
| 8 | 6.46 | 1.46 | 0.18 | 0.27 | 0.06 | 0.12 |
| 9 | 7.27 | 1.64 | 0.18 | 0.36 | 0.06 | 0.12 |
| 10 | 8.07 | 1.82 | 0.18 | 0.46 | 0.06 | 0.12 |
| 11 | 8.88 | 2.00 | 0.18 | 0.56 | 0.06 | 0.12 |
| 12 | 9.69 | 2.19 | 0.19 | 0.68 | 0.07 | 0.12 |
| 13 | 18.24 | 4.12 | 1.93 | 2.14 | 1.46 | 0.47 |
| 14 | 28.50 | 6.43 | 2.31 | 4.17 | 2.03 | 0.28 |
| 15 | 41.32 | 9.33 | 2.90 | 6.88 | 2.71 | 0.19 |
| 16 | 73.80 | 16.66 | 7.33 | 13.99 | 7.11 | 0.22 |
| 17 | 85.76 | 19.36 | 2.70 | 16.65 | 2.58 | 0.12 |
| 18 | 95.16 | 21.48 | 2.12 | 18.75 | 2.00 | 0.12 |
| 19 | 95.97 | 21.66 | 0.18 | 18.92 | 0.06 | 0.12 |
| 20 | 96.78 | 21.84 | 0.18 | 19.10 | 0.06 | 0.12 |
| 21 | 97.59 | 22.03 | 0.19 | 19.29 | 0.07 | 0.12 |
| 22 | 98.39 | 22.21 | 0.18 | 19.47 | 0.06 | 0.12 |
| 23 | 99.20 | 22.39 | 0.18 | 19.65 | 0.06 | 0.12 |
| 24 | 100.00 | 22.57 | 0.18 | 19.82 | 0.06 | 0.12 |

SOIL GROUP "C" ; USING CN 80

* MINIMUM LOSS RATE OF 0.12"/HR USED FOR REMAINDER OF STORM